TRANSACTIONS

OF THE

Illinois State Academy of Science

FOURTEENTH ANNUAL MEETING

Southern Illinois State Normal University
Carbondale, Illinois

April 29th and 30th, 1921

VOLUME XIV

OHIO STATE
UNIVERSITY

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OFFICERS AND COMMITTEES FOR 1921-22

President, CHARLES T. KNIPP, University of Illinois, Urbana.
Vice-President, RUTH MARSHALL, Rockford College, Rockford.
Secretary, C. FRANK PHIPPS, State Teachers' College, DeKalb.
Treasurer, W. F. SCHULZ, University of Illinois, Urbana.
Librarian, A. R. CROOK, State Museum, Springfield.

The Council.

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W. H. HAAS, Northwestern University, Evanston.
W. H. PACKARD, Bradley Institute, Peoria.
STUART WELLER, University of Chicago, Chicago.

Committee on Ecological Survey.

HENRY C. COWLES, University of Chicago, Chicago, Chairman.
GEO. D. FULLER, University of Chicago, Chicago.
W. G. WATERMAN, Northwestern University, Evanston.
V. E. SHELFORD, University of Illinois, Urbana.
W. B. MCDOUGALL, University of Illinois, Urbana.
R. B. MILLER, State Natural History Survey, Urbana.
S. A. FORBES, University of Illinois, Urbana.
A. G. VESTAL, State Normal School, Charleston.
H. S. PEPOON, Lake View High School, Chicago.
CLARENCE BONNELL, Harrisburg Twp. High School, Harrisburg.

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J. C. HESSLER, Knox College, Galesburg, Chairman.
C. M. TURTON, 2059 E. 72nd Street, Chicago.
FRANK H. COLYER, Carbondale State Normal University.
HARRIET STRONG, Northwestern College, Naperville.

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THE SECRETARY.
GEORGE D. FULLER, University of Chicago, Chicago.

PAST OFFICERS OF THE ACADEMY

1908

President, T. C. CHAMBERLIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum of Natural History.
Treasurer, J. C. HESSLER, James Millikin University.

1909

President, S. A. FORBES, University of Illinois.
Vice-President, JOHN M. COULTER, University of Chicago.
Secretary, A. R. CROOK, State Museum of Natural History.
Treasurer, J. C. HESSLER, James Millikin University.

1910

President, JOHN M. COULTER, University of Chicago.
Vice-President, R. O. GRAHAM, Illinois Wesleyan University.
Secretary, A. R. CROOK, State Museum of Natural History.
Treasurer, J. C. HESSLER, James Millikin University.

1911

President, W. A. NOYES, University of Illinois.
Vice-President, J. C. UDDEN, University of Texas.
Secretary, FRANK C. BAKER, Chicago Academy of Science.
Treasurer, J. C. HESSLER, James Millikin University.

1912

President, HENRY CREW, Northwestern University.
Vice-President, A. R. CROOK, State Museum of Natural History.
Secretary, OTIS W. CALDWELL, University of Chicago.
Treasurer, J. C. HESSLER, James Millikin University.

1913

President, FRANK W. DEWOLF, State Geological Survey.
Vice-President, H. S. PEPOON, Lake View High School, Chicago.
Secretary, E. N. TRANSEAU, Eastern Illinois Normal School.
Treasurer, J. C. HESSLER, James Millikin University.

1914

President, A. R. CROOK, State Museum, Springfield.
Vice-President, U. S. GRANT, Northwestern University, Evanston.
Secretary, EDGAR N. TRANSEAU, Eastern State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1915

President, U. S. GRANT, Northwestern University, Evanston.
Vice-President, E. W. WASHBURN, University of Illinois, Urbana.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.

1916

President, WILLIAM TRELEASE, University of Illinois, Urbana.
Vice-President, H. E. GRIFFITH, Knox College, Galesburg.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

1917

President, J. C. HESSLER, James Millikin University, Decatur.
Vice-President, JAMES H. FERRIS, Joliet.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1918

President, R. D. SALLISBURY, University of Chicago, Chicago.
Vice-President, ISABEL S. SMITH, Illinois College, Jacksonville.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1919

President, HENRY B. WARD, University of Illinois, Urbana.
Vice-President, GEO. D. FULLER, University of Chicago, Chicago.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University, Evanston.
Librarian, A. R. CROOK, State Museum, Springfield.

1920

President, HENRY C. COWLES, University of Chicago, Chicago.
Vice-President, CHAS. T. KNIPP, University of Illinois, Urbana.
Secretary, *J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University, Evanston.
Librarian, A. R. CROOK, State Museum, Springfield.

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* Died in 1920. DR. A. R. CROOK acted as Secretary for the remainder of the year.

REPORT OF THE SECRETARY

COUNCIL MEETING

Chicago, September 28, 1920

At the call of President Cowles a meeting of the Council was held at the University Club, 11:30 A. M. There were present President Cowles, retiring President Ward, Vice-President Knipp, Treasurer Waterman and Librarian Crook.

The first question taken up was how best to meet the great misfortune which had befallen the Academy in the death of Secretary Pricer. It was voted that the librarian continue until the next meeting to serve as secretary, as he had been doing at the request of the president since the death of Secretary Pricer. With some misgivings as to the wisdom of such appointment the librarian consented.

In conformity with action at the Danville meeting the following legislative committee was appointed:

H. C. Cowles, Chairman, Chicago.
William Barnes, Decatur.
E. W. Payne, Springfield.
R. M. Barnes, Lacon.
Geo. Langford, Joliet.

It was voted that the fiscal year of the Academy begin with the calendar year and that dues be payable on the December 1st preceding, to accord with arrangements with the A. A. A. S.

The secretary was instructed to mail the three volumes of Transactions which are to appear shortly, to paid-up members only.

It was decided to hold the annual meeting for 1921 at Carbondale some time in the Spring with the hope of having a field day, and the president was requested to begin arrangements for such meeting.

The president was requested to appoint chairmen for the various sections which it might seem advisable to form at the coming meeting.

The treasurer presented matters concerning various classes of members and the relation between the State Academy and the A. A. A. S.

It was suggested that he publish a list of members whose address is unknown, in hope that some member can supply the information wanted.

The following committee was appointed to continue the work of interesting high school science clubs, other science clubs, boards of education, teachers, etc., in the work of the Academy and to suggest to them the desirability of sending delegates to Academy meetings:

Charles T. Knipp, Chairman, Urbana.
W. G. Waterman, Evanston.
R. H. Linkins, Normal.
H. S. Pepoon, Chicago.

Adjourned.

A. R. CROOK,
Acting Secretary.

Office of the Acting Secretary
STATE MUSEUM
Springfield, Ill.
COUNCIL MEETING

On Dec. 27, 1920, President Cowles called a meeting of the council at the University of Chicago to take up several items of business. Those present were Cowles, Ward, Knipp, Waterman and Crook.

The names of a number of candidates who had qualified for membership since the Danville meeting were voted upon.

The acting secretary reported that Vols. XI, XII and XIII of the Transactions were promised by the printer for delivery before Feb. 1st.*

*But one volume has thus far been received. The other two are promised within two weeks.

The treasurer reported that members were promptly paying their dues and thus obtaining the advantage of the reduced rate.

Persons who join the Academy now may, upon request of the secretary, receive $7.00 worth of books free as long as the supply lasts. (Transactions, Volumes XI, XII and XIII and "Guide to the Mineral Collections.") All members in good standing will receive three volumes within the next three months and the "Guide" upon request.

Vice-President Knipp was appointed to represent the Illinois State Academy on the council of the A. A. A. S.

NEXT MEETING

The men of science at Carbondale are cordial in their invitation to the Academy and enthusiastic in preparations for the meeting which will be held April 29th and 30th.

One full day will be devoted to papers and one to a field trip.

The program will deal largely with local scientific problems. Few people who have not visited the region have any idea of its beauty or of its interesting biological and geological features.

A. R. CROOK,
Acting Secretary.

Feb. 7, 1921.

Illinois State Academy of Science
FOURTEENTH ANNUAL MEETING
Carbondale, April 29-30, 1921

The meeting was enjoyed greatly by the sixty-five members in attendance.

The officers of the Academy reached Carbondale the day before the meeting and together with the local committee completed arrangements so that the program of papers and excursions proceeded in good order.

Dr. Shryock, president of the Southern Illinois State Normal, welcomed the Academy to Carbondale, and President Cowles responded.

The acting secretary gave some facts concerning the publication of three volumes of Transactions and reported that the volumes had been mailed to all members.

The treasurer's report showed a balance of $704.23, the largest in the history of the Academy.

Reports were made by Prof. Cowles for the committee on Ecological Survey and the committee on Legislation. Prof. Barber reported for the committee on Secondary School Science and Prof. Knipp for the committee on High School Science Clubs. Prof. Van Cleave for the committee on Membership read a list of 155 names of candidates, the largest list presented at an annual meeting.

Throughout the meeting there were many expressions of appreciation at the happy way in which the presiding officer handled situations indoors and out, and also of regret that the treasurer who had been serving the Academy so skillfully for the last years did not see his way clear to continue in office.

The new officers are so modest that the librarian agreed to send out this notice of their election. We wish them the greatest success in their work. Future communication should be addressed as below.

NEW OFFICERS

For the Year 1921-1922

President,	CHARLES T. KNIPP,	Urbana.
Vice-President,	MISS RUTH MARSHALL,	Rockford.
Secretary,	C. FRANK PHIPPS,	DeKalb.
Treasurer,	W. F. SCHULZ,	Urbana.

(Signed)

A. R. CROOK,
Librarian.

Illinois State Academy of Science
FOURTEENTH ANNUAL MEETING
Carbondale, April 29-30, 1921

MINUTES

After the call to order by President Cowles, an address of welcome was made by President Shryock of the Southern Illinois Normal University and was responded to by President Cowles.

Reports of committees were then called for. The acting secretary announced the loss to the Academy occasioned by the death during the past year of Miss Grace J. Baird, H. L. Roberts and Secretary Pricer. In a notice of the council meeting held last November sent to Academy members, expression had been given to the feeling of deep sorrow at the loss of Secretary Pricer who for years had served the Academy faithfully and well. At the request of the council, the librarian took up the work of the secretary's office in September and pushed it forward as rapidly as possible. The conditions were unusually difficult since there were three volumes to be handled. Manuscripts, illustrations and proof were in considerable confusion. Many authors had neglected to label illustrations and in some cases it was difficult to place the photographs with the proper article. Because of the effect of the war on prices the printers losing money did not wish the work, and hence were incredibly slow and careless. The secretary's office used every possible means to expedite matters and finally all three volumes were mailed to the membership before time of the meeting.

During the past year about 155 new names were added to the roll of members—the largest increase during any year of the Academy's history. The membership now contains 554 names.

During the last seven months about ten thousand pieces of mail matter have been sent from the secretary's office.

The treasurer submitted his report for the year 1920-1921. (See Treasurer's Report.)

The president appointed the following auditing committee: Stuart Weller, Clarence Bonnell and C. E. Montgomery.

Next in order came the reports of committees. President Cowles reported for the committee on ecological survey as follows:

REPORT OF THE COMMITTEE ON ECOLOGICAL SURVEY, 1920-1921

During the past season, this committee has been rather inactive, except for the work of individual members. The undersigned, with various of his students, has continued the work previously begun in Cook County; most of the townships in this county have now been surveyed, and maps with descriptive texts have been prepared. Prof. Waterman has made a survey of a number of the bog areas in Lake County, and has prepared a preliminary report of this work for the Carbondale meeting. Prof. Fuller and State Forester Miller have made forest studies of an ecological nature in Alexander County, also reported in the Carbondale meeting.

HENRY C. COWLES,
Chairman.

President Cowles also reported that the legislation committee had met the appropriation committee of the State Senate and House, and that there was every reason to believe that the state would continue the publication of the Transactions of the Academy as during the past two years.

Prof. Barber reported that the committee on the condition of science courses in the secondary schools did not at this time desire to make any report. An extensive report had been presented in Volume XI.

Prof. Knipp for the committee on High School science clubs reported sending out letters to High Schools in the southern portion of the state, calling attention to the opportunity of sending delegates to the State Academy meeting. He suggested that this work be continued in other parts of the state.

Prof. Van Cleave for the committee on membership read a list of 155 names of candidates, the largest list presented at any annual meeting. These candidates were voted in.

The president appointed the following committees. On nominations: E. R. Downing, W. G. Waterman. On resolutions: C. F. Phipps, Miss Isabel Smith and Miss Mabel Sykes.

After the business meeting the Academy adjourned to the fine chapel room where, seated upon the platform, after remarks by the president of the school and of the Academy, the members were introduced to the nine hundred students present. Each member rose and stated his name, place of residence and occupation, furnishing a fine illustration of the fact that all parts of the state and a great variety of sciences are represented in the Academy. Each was greeted with applause.

After an excellent luncheon together in Anthony Hall, the invitation addresses were delivered in Zetetic Hall on the general subject of nature and man in southern Illinois.

The auditing committée reported that they had examined the books of the treasurer and found them to be correct. On motion the treasurer's report was then adopted.

The nominating committee presented the following names for officers for the coming year: President, Chas. T. Knipp, Urbana; Vice-President, Miss Ruth Marshall, Rockford; Secretary, C. Frank Phipps, DeKalb; Treasurer, W. F. Schulz, Urbana; a third member on Publication Committee, Geo. D. Fuller; Committee on Membership, C. F. Hottes, W. H. Haas, W. H. Packard, Stuart Weller.

On motion these officers and committees were elected.

The committee on resolutions presented the following resolutions in regard to the death of members of the Academy and on motion they were adopted: "The Illinois State Academy of Science has lost three of its members by death during the past year and we take this opportunity to express a word of appreciation of these late members and of their work. We mourn the death of J. L. Pricer who

for years as secretary gave loyal service to this organization. We mourn the loss of Miss Grace J. Baird who brought to her botany classes in the Bowen High School, Chicago, a rich scholarship and a deep human interest which made her an ideal teacher. We mourn the loss of H. L. Roberts, teacher of geography at Cape Girardeau, Mo., a member of the Academy for twelve years. He lost his life in Current River on a research trip in the Ozark mountains.

Be it resolved that a copy of the above expressions concerning our late friends be spread upon the minutes of this annual meeting of the Academy."

The committee on resolutions next presented the following appreciation of the hospitality shown the Academy: "The members of the Academy greatly appreciate the hospitable reception accorded them by the citizens of the southern part of the state, and realize how much thought and planning has been given toward making this a most comfortable, enjoyable and successful meeting. We hereby desire to express our sincere and grateful thanks to the president and faculty of the Illinois Southern Normal University, to the people of Carbondale and Murphysboro for what they have done and are planning to do to make this meeting one of outstanding success. It is hereby resolved that an expression of our appreciation be spread upon the minutes of the meeting, and that a copy be sent to the President of the Illinois Southern Normal University."

On motion these resolutions were adopted.

President Cowles presented a suggestion by Professor Townsend of the University of Illinois to invite the Illinois Branch of the Mathematical Association of America to meet in connection with the annual gatherings of the State Academy. It was voted to extend an invitation to them to do so.

A delightful banquet preceded the evening address by the retiring president—an illustrated lecture on the state park movement. The audience which comfortably filled the auditorium of the church greatly appreciated the lecture.

Two days of interesting excursions followed the papers—an innovation with our Academy.

The weather was favorable; the physiographical, geological, botanical and zoological features were interesting.

The citizens of Murphysboro conveyed the company in automobiles to Fountain Bluff, and after several hours tramping over the hills the company were in proper condition to enjoy the barbecue so hospitably prepared.

The excursion taken to Fern Cliff the following day will long be remembered because of the many interesting scientific and scenic features and the hospitality of our hosts.

A cordial invitation was received from the president and scientific faculty of Rockford College to hold the next meeting in Rockford.

A. R. CROOK,
Acting Secretary.

TREASURER'S REPORT

Balance on hand for the year 1919-1920	$ 56.53
Received from dues (Initiation and Annual)	988.15
A. A. A. S. Dues collected by the Academy	1,092.50
Received from the sale of Transactions	24.25
Received for stamps from State Appropriation	75.00
Total receipts	$2,236.43

EXPENDITURES

Paid for stationery, postage and other expenses of officers	$ 159.27
Paid for bill to Miller Printing Co., for balance on Volume X	103.95
Paid for current printing	147.31
Paid A. A. A. S. for dues collected	1,092.50
Paid for exchange	7.67
Amounts refunded	21.50
	$1,532.20
Balance on hand April 27, 1921	704.23
Total	$2,236.43

W. G. WATERMAN, Treasurer.

We, the undersigned, have examined the above accounts and have checked the amounts against the vouchers. We find the same correct.

Signed: STUART WELLER,
CLARENCE BONNELL,
C. E. MONTGOMERY.

Papers of General Interest—
Invitation Addresses

SOME EVENTS IN THE GEOLOGICAL HISTORY OF SOUTHERN ILLINOIS

PROF. STUART WELLER, UNIVERSITY OF CHICAGO

From a geological point of view southern Illinois, along with southeastern Indiana, occupies a basin lying between the Ozark region of Missouri on the west, and the Cincinnati region on the east. Throughout geological time these two areas have been positive areas, that is regions which have had a tendency to be uplifted at intervals to a greater degree than their surroundings. At times they have been islands completely encircled by the waters of the ancient seas, at other times they have been covered by waters of much shallower depth than the adjacent areas.

In discussing the geological history of this area, as of any region, the geologist must draw his inferences concerning the succession of events from his field observations upon the rock strata of the earth's crust. Since geological time is inconceivably long, and since the complexity of geological history is exceedingly great, a consideration of the entire course of the geological history of southern Illinois would consume time far beyond that at my disposal this afternoon. I will, therefore, confine my remarks to a comparatively short time interval, namely that beginning with the Mississippian period and extending to the close of the Paleozoic era.

Rock strata of Mississippian age occupy a belt, including the Mississippi river bluffs and the adjacent region to the east for a distance of 15 miles or less, extending from a point in St. Clair County south of East St. Louis, to the valley of Big Muddy river. Strata of the same age occupy another belt extending eastwardly across Union, Johnson, Pope and Hardin Counties, from the Mississippi river to the Ohio, south of the Ozark upland which occupies the northern portion of the counties mentioned.

Throughout Mississippian time the southern Illinois basin was occupied by a great gulf-like embayment of the ocean which opened to the south; it was in a way an extension to the north of the ancient Gulf of Mexico. This embayment extended far beyond the limits of the present outcrops of

Mississippian formations, for in large areas these strata are now covered by younger sediments, and elsewhere they may have been removed by the processes of erosion since the time of their deposition. With the more or less rhythmic fluctuations of the ocean level during the Mississippian period, the shore line of the basin was constantly undergoing change. When the relative level of the ocean was raised, the shore-line advanced inland, just as the shore line of the present Gulf of Mexico would advance if the present ocean level were raised in relation to the land surface. At other times the waters of the basin were withdrawn so that it became much contracted in size, and not a few times the waters retreated entirely and the basin became a part of the continental dry land. The records of all these changes have been preserved in the rock strata, and from a study of the characters of the rocks themselves, their faunal contents, and the geographic distribution of the several formations, the geologist is able to arrive at some conclusions concerning the geological history.

A cursory examination of the Mississippian formations of southern Illinois brings clearly into view two divisions of the system as a whole. The lower portion of the section is made up of a succession of limestone formations, containing some shale or clay layers, but with almost no sandstone strata. The upper portion of the section is made up of a succession of alternating sandstone and limestone-shale formations, giving to the upper and lower divisions of the System distinctly different characteristics. On the basis of the lithologic characters alone the Mississippian System of this basin may be rather sharply differentiated into a Lower Mississippian and an Upper Mississippian Series, and when the evidence of the fossil faunas and the geographic distribution of the several formations are considered, such a differentiation is clearly established. In some recent literature these two divisions of the Mississippian have been called the Iowa Series and the Chester Series.

As has been indicated already, the Iowa or Lower Mississippian Series is made up almost entirely of a succession of limestone formations, there being but few thin sandstone beds. This succession of formations was largely differen-

tiated near the middle of the last century, and the formations defined by James Hall, with some few modifications and additions, are recognized to this day. In this Series the formations now generally recognized are as follows, beginning with the uppermost one.

7. Ste. Genevieve limestone.
6. St. Louis limestone.
5. Spergen or Salem limestone.
4. Warsaw limestone and shale.
3. Keokuk limestone.
2. Burlington limestone.
1. Kinderhook Group.

The oldest unit in this series, the Kinderhook Group, is really made up of numerous local formations, including sandstones, shales, and limestones. Throughout southern Illinois and adjacent regions, where outcrops of these beds are known, they everywhere exhibit a relation of unconformity with the underlying strata, a relation which shows that the whole area has been a dry land surface immediately preceding Mississippian time. This condition accounts for the notable heterogeneity of the Kinderhook beds. The period was one of sea advancement during which the basin was bordered by lands from which various sorts of clastic materials were being transported into the sea, in one place mud to form shale, in another place sand to form sandstone, and elsewhere in some sheltered situation where land detritus could not reach, limestone beds were accumulated. With the progressive advancement of the shore lines and the gradual submergence of the bordering land areas, the sources of clastic materials were gradually eliminated, and the sedimentary deposits became limestone derived from the skeletons of lime secreting organisms.

In Burlington time, while the limestone of that name was being accumulated, the submergence had proceeded so far, as is shown by the distribution of the characteristic fossils of Burlington age, that Ozarkia to the west of the basin was largely or wholly under water, and the shore line at the head of the embayment lay somewhere north of the present site of Chicago. The waters connected with this basin spread

westward across Iowa and probably reached to the Rocky Mountain region. Cincinnatia was a low lying island or shoal water area. During this time, with no immediate source for terrestrial materials, the sediments accumulating over southern Illinois were largely calcium carbonate of organic origin, along with considerable quantities of colloidal silica which was precipitated from fresh waters entering the basin from rivers. Near the shore line clastic deposits must have been accumulating, but they did not reach to the area now occupied by southern Illinois.

After Burlington time the waters of the Illinois basin underwent a number of withdrawals and readvancements, but the waters of the basin probably had their greatest extension during the Burlington epoch. The Keokuk epoch was initiated by partial withdrawal of the waters of the basin, the northern shore line coming to occupy such a position that terrigenous material in the form of fine mud was somewhat extensively deposited as shale beds, as far south as southeastern Iowa and the adjacent parts of Missouri and Illinois, while in Burlington time the sedimentary accumulation in these same areas was wholly organic in origin. That part of the basin which is now southern Illinois, however, still remained at such a great distance from the shore lines that limestone accumulations continued uninterruptedly through the Burlington and Keokuk time, making it more difficult to separate the strata of these two epochs. In Warsaw time the shore line shifted still farther to the south, and by mid-Warsaw time it occupied a position somewhere between the southern border of Iowa and the city of St. Louis. At this time also, the ocean level was sufficiently lowered to permit the streams of Ozarkia to carry terrigenous material into the sea, so that the Warsaw formation of southern Illinois contains notable shale deposits, especially in the Mississippi river sections, although in southern Illinois, at a greater distance from the shore line, the sedimentation was continuously limestone.

Following Warsaw time there was a readvance of the northern shore line until the waters of the Illinois basin spread again into northern Illinois, and westward into Iowa for an unknown distance, and completely surrounded the

Ozark land which was sufficiently submerged to prevent any transportation of land detritus by the streams into the surrounding oceans. It was at this time that the Spergen limestone was being laid down, a formation which is a nearly pure limestone at most localities. In southeastern Iowa this formation lies unconformably upon the underlying beds, but in the southern portion of the basin there is no evidence of any interruption in sedimentation in passing from the Warsaw to the Spergen. If the exact southern limit of the condition of unconformity could be determined, the exact location of the southernmost position of the shore line in late Warsaw time could be established.

After Spergen time the waters of the Illinois basin again retreated southward to a position essentially the same as that of the pre-Spergen retreat. The evidence for this shifting of the shore line is exhibited in the uncomformable contact of the St. Louis limestone which lies next above the Spergen, or above whatever formation is subjacent. During the post-Spergen retreat the erosion of the surface of what is now southeastern Iowa was unequal, in places the whole of the Spergen was removed, while elsewhere a greater or less thickness of the formation remained. Where the Spergen was wholly removed the St. Louis limestone rests directly upon the Warsaw beds; elsewhere it rests uncomformably upon the Spergen. In southern Illinois the continuity of sedimentation from Spergen to St. Louis time was not interrupted, a condition indicating the continuous occupation of that portion of the Illinois basin by the ocean waters. The southern extent of the post-Spergen unconformity seems to be essentially the same as that of the post-Warsaw, and so far as can be determined from data now available, the shore lines of these times occupied about the same positions.

Again a fluctuation of the waters of the basin took place in the midst of the period of deposition of the St. Louis limestone, this withdrawal, followed by a readvance, being proven by a stratigraphic break in southeastern Iowa with the upper division of the St. Louis limestone resting uncomformably upon the lower portion of the same formation. This interruption is exhibited as far south as Alton, Illinois,

by a conspicuous brecciated layer in the midst of the St. Louis limestone, but south of the city of St. Louis no break in the record is recognizable. This mid-St. Louis withdrawal, to a position as far south as Alton, was greater than either of the preceding ones had been.

At the close of St. Louis time the waters of the basin were again withdrawn, and this withdrawal was even greater than that of the mid-St. Louis, for the unconformity between the St. Louis and the overlying Ste. Genevieve limestone extends as far south as Ste. Genevieve, Missouri. In the Ohio river sections of the Mississippian formations, however, there is no stratigraphic break between these two formations, a condition which shows that the waters of the Illinois basin were not completely withdrawn from the southern part of Illinois at this time. With the readvance of the Ste. Genevieve sea, the waters again occupied much of Illinois and spread westward, north of the Ozark land, to a point at least as far west as Fort Dodge, Iowa, which is 175 miles from the Mississippi river, and the waters may have extended much farther than this for the record is now completely buried beneath younger formations.

With each one of these readvances of the waters in Lower Mississippian time, the sea-pattern developed in the Illinois basin must have been essentially similar in its general outline, although in detail undoubtedly there was much variation, but with the close of the Lower Mississippian, the Iowa series, after the deposition of the Ste. Genevieve limestone, the waters were more completely withdrawn than they had been at any time since the opening of the Mississippian. This withdrawal may have been from the entire continental area, although this cannot be certainly asserted.

With the opening of Upper Mississippian or Chester time, the oceanic waters again occupied the Illinois basin, but the sea-pattern of this epoch was totally different from that of Iowa time. During the Chester the embayment never extended westward, north of the Ozark land, as it had done in Iowa time, that land area being continuously connected to the north, across Missouri and Iowa, with the main land. The Illinois basin of Chester time was limited

to the area between Ozarkia and Cincinnatia, and the head of the bay, as determined by deep well records, probably did not extend north of the present site of Decatur, Illinois.

The succession of events during Chester time in the basin consisted of a rhythmic series of advances and withdrawals of the waters, with a consequent shifting of the shore lines, similar to those which had taken place during Iowa time. The sediments which accumulated in the basin during this time were very different from those of Iowa time when there was little but limestone, for there are extensive sandstone formations, and much shale is associated with the limestone formations of the series. Where the Chester section is most complete, in Pope and Johnson Counties, Illinois, there is an alternating succession of sandstone and limestone-shale formations, there being eight of these pairs, or sixteen recognized formations in all. Each one of these pairs of formations must represent a separate advance and retreat of the waters of the basin, with the consequent shifting of the shore line of the embayment alternately to the north and to the south. During several of the periods of withdrawal of the waters, the entire area of the basin north of the present Ohio river must have been emergent, forming a part of the dry land surface stretching away to the north, northwest, and northeast. The evidence of such complete withdrawal is the relation of unconformity which exists at a number of horizons between a limestone formation of the series, and the next succeeding sandstone.

In general the sandstones must have accumulated in proximity to the shore lines. With the advancing sea the waves were constantly working over the accumulations of beach sands, great quantities of which were spread over the shallower portion of the sea bottom. With the advancing shore line a given point would be situated successively on dry land, on the beach, in shallow water, and finally in deeper water at a distance from the shore beyond where the sand was being deposited, where fine mud and calcareous sediments were accumulating. With the withdrawal of the waters of the basin the reverse process must have taken place. Deeper waters would become progressively shallower and the wave movements of the waters would

again initiate the distribution of sands over regions which had been limestone-shale depositing areas. These newer sand deposits, however, would soon become a part of the dry land surface where they would be subject to erosion, and a large portion of the material would be washed down again into the sea to be reworked by the waves, and eventually the final land surface would be constituted of the limestone strata which had been deposited at some distance off shore. With the next advance of the waters in the basin the calcareous land surface would become the floor upon which the next succeeding sandstone formation was deposited unconformably.

It is not clear that every one of the Chester sandstone formations which have been recognized in southern Illinois exhibits a condition of unconformity along its belt of outcrop with the underlying limestone, but the presence of unconformity or the lack of such a relation at these horizons is indicative of the position of the fluctuating Chester shore lines relative to the present outcropping belt of the formations. In the greater withdrawals of the waters of the basin the whole of southern Illinois doubtless became a part of the dry land surface, but in the lesser withdrawals the extreme southern position of the shore line was north of the present position of the Ohio river. During the entire succession of events of Chester time, the shifting shore lines must have repeatedly occupied every part of southern Illinois.

The original source of the sand which was finally consolidated in the sandstone formations of the Chester series may have been far away. Rivers draining the country far to the north must have emptied into the Illinois embayment during this time, and the sand and silt transported by them, perhaps from as far away as the Canadian highlands, may have been the original source of much of the material. The Ozark land to the west was probably a low lying region during much of the time, with sluggish streams which did not bring much land detritus into the basin, and there is no evidence that Cincinnatia was ever at any great elevation above the sea. The fact that several of the Chester sandstones become much reduced in thickness to the west is perhaps

evidence that the streams bringing the sand had their mouths toward the eastern side of the basin, the thicker portions of the formations being nearer the source of supply of the material. One of these formations, which has been named the Waltersburg sandstone, is conspicuously developed in proximity to the Johnson-Pope County line but thins to the east and the west, the lateral extent of the formation in an east west direction along the belt of outcrop, as a conspicuous member of the section, being not greater than forty miles. It is not improbable that this formation may have accumulated as a delta deposit opposite the mouth of a river entering the basin at this particular time in its history.

If the suggested interpretation of the succession of Chester sandstones and limestone-shale formations of southern Illinois is the correct one, then it would be expected that this same time interval would be represented by more continuous limestone strata at a distance from the shore line of the Illinois basin. The Chester Series is extensively represented in southeastern Tennessee and northeastern Alabama by a thick limestone formation which probably represents the whole succession of limestone-shale formations in southern Illinois. Only one thin sandstone member has been recognized in southeastern Tennessee which seems to occupy the position of the Hardinsburg sandstone of the Ohio valley. A similar sandstone which may be the same is present in the Alabama section.

With the final withdrawal of the waters of the Chester seas the Mississippian period came to an end and southern Illinois became a portion of a widely stretching dry land area, and remained in that condition for a long period of time. This land surface was sculptured by the action of streams which drained the area, and the whole surface doubtless was covered with a strange vegetation, very different from that of the present time. No record of this land life is preserved in our own state, but elsewhere sediments have been preserved, containing many fossil plants, which were deposited during this dry land period in Illinois. Finally a change in conditions was inaugurated, and

there began to accumulate a great series of sediments which were terrestrial in origin rather than marine. These sediments consist of extensive beds of cross-bedded sandstones which are commonly coarser in texture than the Chester sandstones, some beds of which include great numbers of smoothly rounded, white, quartz pebbles which vary in size from one-fourth of an inch to nearly an inch in diameter. These pebble beds or conglomerates are highly characteristic of the Pottsville formation, and are widely distributed in the hills of the elevated country crossing Illinois south of Carbondale. Associated with the Pottsville sandstones and conglomerates there are important beds of shale and more or less thinly bedded sandstones, and also locally some coal beds. The fossil remains which have been preserved in the Pottsville beds are land plants. More or less fragmentary trunks of the Carboniferous tree, *Lepidodendron*, are present in many places in the sandstones, and the shales in places contain abundant, well preserved plants, most of which are ferns or fern-like forms.

Pottsville formations quite similar to those in southern Illinois are widely distributed in North America. They are present in the sections as far away to the southeast as southeastern Tennessee, and northern Alabama, and to the southwest they extend into northern Arkansas. The exact conditions under which such formations could have accumulated are not easy to visualize. The source of the materials in these Pottsville beds, including the vast numbers of white quartz pebbles, is still a mystery to the geologist, and the manner in which they may have been spread so widely upon the land surface is not clear. Doubtless the land was low lying, and broadly meandering streams probably were an agent in spreading the materials. There must also have been estuaries, and broad, shallow basins occupied by waters in which quantities of mud accumulated, in which were buried in places the remains of some of the plants which lived near at hand.

There are a few records in southern Illinois of a thin limestone in this Pottsville series containing marine fossils, which bears evidence that once at least, marine conditions spread into southern Illinois in Pottsville time, remaining

for a short period only. After Pottsville time similar conditions persisted in southern Illinois through the period of deposition of the Carbondale and McLeansboro formations. The main coal beds which are so widely mined in southern Illinois are all included in the Carbondale formation. The McLeansboro also contains several thin coal seams, none of which, however, are workable. During all of this time the elevation of the whole of the Illinois basin must have been near sea level. During the intervals of coal formation great swamps covered the area, where the coal plants grew and where the beds of peat accumulated which later became changed to coal. At times these coal swamps were widely distributed and of long duration. At other times the coal swamps were local and of comparatively short duration. Between the periods of coal accumulation the basin was sometimes occupied by shallow, marine waters in which shale beds of impure limestones were formed, the marine origin of such beds being established by the presence of the marine fossils which are included in them. Other members of the Carbondale and McLeansboro formations doubtless were terrestrial in origin, similar to much of the sandstone and shale of the Pottsville formation.

After the close of Pennsylvanian time there was an exceedingly long period which has left no sedimentary record of the events which transpired, but during this time there was a period of notable deformation of the rocks of the earth's crust. This deformation resulted in uplift, and locally in the development of great fractures or faults through the rock strata, with differential movement of the blocks adjoining the fractures. The presence of the elevated belt of land across Illinois from the Mississippi to the Ohio river, south of Carbondale, is due to this deformation. The rocks constituting the summits of this range of hills are Pottsville in age, but at Carbondale and throughout the level country north of the hills the same Pottsville strata lie many feet beneath the surface. The amount of uplift along this belt must be equal to the difference between the elevation of the summits of the hills and the depth of the same Pottsville beds beneath the surface, to the north, and must amount to 1000 feet or more. The geology of the belt has

not been mapped in detail except for a short distance near Shawneetown on the Ohio river, where east-west faulting has been observed, but this faulting may not extend across the State. On the southern slope of the Ozark hills a remarkable series of faults has been mapped in Hardin, Pope and Johnson Counties.

The exact time when all of this faulting occurred cannot be determined with certainty. The deformation must have taken place after Pennsylvanian time for the strata of Pennsylvanian age are involved. The other limit which can be established is determined by the age of the gulf embayment deposits which stretch from the Gulf of Mexico coast line to southern Illinois. These deposits overlie the faulted rocks under consideration in an undisturbed condition. The age of the oldest of the embayment deposits is probably Cretaceous, so the age of the faulting would fall between the Pennsylvanian and the Cretaceous, a very long period of time, even to the Geologist. Within these time limits falls the close of the Paleozoic era, a time when much deformation was in progress in many parts of the world, and it is commonly assumed that the faulting in southern Illinois was accomplished, in the main, at that time.

In Hardin County it is significant that associated with the faults are found the remarkable deposits of fluorspar for which southern Illinois is famous, and also there are present in the same region numerous dikes of igneous rocks which penetrate the limestones and other formations of Mississippian and Pennsylvanian age. It is believed that there is some definite connection between the three phenomena, the faults, the mineral veins, and the igneous dikes. There is probably a considerable area of southeastern Illinois and the adjoining portion of Kentucky which is underlain by a great mass of igneous rock. This was in effect the site of a great volcano in the long distant past, most of whose lava was injected into and between the sedimentary rock strata. If any of the lava was ever extrusive on the surface, it has long since been removed by the processes of erosion. Numerous dikes, some of which may have extended to the surface when they were formed, are known to be present, and at least one mass in northern Hardin County,

near Sparks Hill, seems to be an ancient volcanic neck, or outlet. The most western of these dikes which has been observed is in Pope County about one mile west of Golconda. They have been observed at numerous localities in Hardin County, and are known to be present in some of the coal mines near Harrisburg. They have also been observed at many localities in Livingston and Crittenden Counties, Kentucky. Doubtless many other dikes are present within this region wholly covered by the surficial mantle rock, some of which may be discovered in the future. The depth beneath the present surface, of the great body of igneous rock with which these dikes must connect, is unknown, for it has never been pentrated either in mining operations or by deep drilling.

The presence of such an intrusion is believed to be responsible for at least some of the faulting of the region. When the mass was injected into the strata of the crust, the beds overlying it were necessarily bowed up, and in this process of bowing the beds were stretched and great fractures were formed. The amount of movement on opposite sides of these fractures was not the same so that faulting resulted. The faults which were formed during this upbowing process, however, probably were not the most complicated ones. While the deeply buried molten mass was still very hot and remained in a more or less plastic or viscous condition, the enormous weight of the overlying sediments resting upon it must have had a tendency to squeeze it out laterally so that the original dome would become lower and broader. With the readjustment of the crustal blocks in connection with this settling of certain arch-like segments of the dome, there was a virtual collapse of the strata in certain areas, occasioning extremely complicated faulting.

The fluorspar veins of southeastern Illinois are along certain of the faults in the more complexly faulted areas, or in rather close association with faults. The fluorine content of the mineral is a product of igneous rocks and doubtless was originally given off from the igneous rock which presumably underlies the entire fluorspar region. A determination of the actual genesis of the ores as they are found at the present time is complicated by many factors, but Mr. L.

W. Currier has made numerous observations which tend to prove that the present occurrence of the fluorspar is due to a replacement of crystalline calcite which first closed up the open spaces along fault planes.

Not all of the faults of southern Illinois were associated with the deep seated igneous intrusion, for certain of them are far from any known igneous dikes, and there must have been other stresses of the earth's crust at this time which were relieved by faulting. In general the more continuous faults in southeastern Illinois have a northeast-southwest direction. To the southwest they pass beneath the embayment deposits, as has been previously indicated, but it is perhaps significant that the projection of this belt of faulting in a southwesterly direction follows very closely the western border of the area occupied by the embayment deposits, and the suggestion may be offered that this whole embayment area may be the result of a downward dislocation of the crustal block lying southeast of the continuation of the faulting which is exposed across Pope and Hardin Counties, Illinois, but which is hidden to the southwest. Certain structural features as far southwest as northern Louisiana may possibly be associated with this same line of deformation.

Coming from the Ozark region west of the Mississippi river there is a belt of faulting which crosses the river in the vicinity of Grand Tower, Illinois. These faults have an east-west or northwest southeast direction, with the downthrow side on the north, and it is not unlikely that the eastward extension of some portion of this fault belt may be responsible for the uplifted Ozark ridge across southern Illinois.

The widespread distribution of the faults of southern Illinois establishes the fact that this area has been, in the geologic past, one of great crustal disturbance. Lines of weakness once established in the earth's crust repeatedly give way under the accumulating stresses, and it is not unlikely that movements of greater or less magnitude have taken place along certain of these fault lines at intervals since they were first established. It is quite possible that

the New Madrid earthquake of 1811 was the result of movement in some portion of this fault zone.

The events in the geological history of southern Illinois which have been mentioned and briefly discussed in this address constitute only a fragment of the complete history of the region. They are, however, the events which are recorded in the rock strata which are actually exposed in the region. Many hundreds of feet of strata underlie the whole of this portion of the state, beneath the formations which have been considered, but the history which they record is not so easily or so certainly determinable. There is also a long history since the close of Paleozoic time which is full of events of great interest, but neither this more ancient nor the more modern portion of the story can be considered at this time.

THE GEOGRAPHY OF THE OZARKS

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LOCATION AND EXTENT.

The Ozarks, or the Ozark Ridge, is the name commonly applied to the rugged highland that extends entirely across southern Illinois from the Mississippi to the Ohio river. It is really a spur, or an eastern extension of the Ozarks of Missouri. This Illinois spur of the Ozarks is located chiefly in the counties of Union, Johnson, Pope and Hardin, but it also extends into the southern parts of Jackson, Williamson, Saline and Gallatin counties.

The crest of the Ozarks is near the northern boundary of Union, Johnson, Pope and Hardin counties. In Hardin county the crest of the Ozarks is almost exactly on the northern boundary line, but in the case of the other counties the crest is several miles farther south.

The Ozarks extend entirely across southern Illinois and have a total length of 75 miles. While the width of the Ozarks is by no means uniform, still its average is not far from 25 miles.

SURFACE.

From the standpoint of altitude above mean sea level, the so called "mounds" of Jo Davies county is the highest part of Illinois. The highest hill in this region has an elevation of, 1257 feet, which is nearly 200 feet higher than the highest part of the Ozarks.

So far as now known, the highest hill in the Ozarks is William's Hill in the northeastern part of Pope county. This hill has an elevation of 1065 feet above mean sea level. Bald Knob in Union county is, however, only 40 feet lower, with an altitude of 1025 feet. There are a number of hills in the crest of the Ozarks that have an altitude from 900 to 1000 feet.[1]

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1. Weller and Butts: Extract from Bull. No. 41, Ill. State Geological Survey, 1920, pp. 10.

But mere altitude above sea level is, however, often misleading and gives little idea of either the appearance or the importance of a highland.

While it is true that the mounds of Jo Davies county do have an elevation almost 200 feet higher than the highest hill of the Ozarks, still the reader must keep in mind that the general level of Illinois in Jo Davies county is twice as great as that in the region of the Ozarks. For instance, the highest hills in Jo Davies county are only from 200 to 250 feet above the general level of that part of Illinois,[2] while the highest hills in the Ozarks are from 500 to 600 feet above the general level in the southern section of the state. The northern base of the Ozarks at Carbondale, for example, is only 415 feet above sea level, and the southern base of the Ozarks is but little over 300 feet.

It is this difference in altitude between the general level of its surroundings and the tops of the higher hills in the crest of the Ozarks, rather than mere height above sea level, that makes the Ozarks the most conspicuous highland in Illinois. This difference of 500 to 600 feet between crest and base of the Ozarks gives its streams sufficient power to carve this region into a complex of deep valleys and ravines alternating with high narrow crested ridges or steep sided, irregularly shaped hills.

As a whole the Ozarks are in the mature stage of the cycle of erosion; but there are several sections that should not be classed any later than late youth. East of Makanda, in Jackson county, there is a region of considerable size, that has a number of farms on the summit of the Ozarks that are comparatively level. Near the village of Ozark, in Johnson county, there is another region of flat topped hills where the land is comparatively level over a considerable area. There are, no doubt, other regions with similar surface features which can not be regarded as maturely dissected.

It is thus seen that the surface of this upland is by no means alike over the entire highland. The chief reasons for these differences of surface are: First, the amount,

2. Ridgeway: Natural Hist. of Ill., Vol. I, pp. 7.

or degree of stream erosion; second, the character of the rocks immediately beneath the mantle rock; third, the amount and different periods of uplift; fourth, the amount of faulting that occurred during the periods of uplift.

The greatest contrast in surface features is to be seen in the region of the Pottsville sandstones and conglomerates, compared with the section occupied by the less resistant limestones and shales of the Mississippian period. The Pottsville rocks are found in the northern part of the Ozarks while the weaker Mississippian limestones and shales are found in the southern section of the same highlands.

The Pottsville being largely sandstones and conglomerates with the cementing material in many cases iron oxide, these rocks are more resistant than many of the limestones and shales of the Mississippian outcrops in the southern part of the highlands. The Pottsville form a continuous strip of land in the southern part of Jackson, Williamson, Saline, and Gallatin counties and extend somewhat less continuously along the northern boundary of Union, Johnson, Pope, and Hardin counties.

Where the resistant Pottsville rocks are exposed, or lie immediately under the mantle rock, the stream made valleys are characteristically narrow and steep sided, but the hill tops have larger summit areas than the less resistant limestone areas farther south. Not all of the Pottsville area has these flat topped hills, but this is characteristic of much of this region.

In the southern part of the Ozarks, however, the land is maturely dissected and flat hill top farms are rare. The surface consists of a series of deep valleys with ridges or irregularly shaped hills between the valleys.

In certain sections, particularly in Hardin county, faulting has been responsible for certain surface features. Fault lines often represent places of weakness, where streams can more easily develop their valleys. In Hardin county several stream courses are thus determined by fault lines.

There are certain easily dissolved limestones that have caused the characteristic sink hole and underground drain-

age surface. There are two such areas in Hardin county, one in the vicinity of Cave in Rock and the other near Rosiclare. There are other similar areas in Johnson and Pope counties.

Some idea of the ruggedness of the Ozarks can be gained by a more detailed statement of the steepness of the slopes in various parts of this highland region. On the Mobile and Ohio railroad from Pomona to Alto Pass, in a distance of four miles, the altitude changes from 403 to 748 feet, while in the next four miles there is a drop from 748 to 449 feet. Again at Ozark on the Paducah branch of the Illinois Central railroad there is a descent from 668 feet, at Ozark, to 384 feet at Simpson, in a distance of five miles. It should be noted that these are railroad grades and are about the easiest grades that can be found which cross the crest of the Ozarks. Most of the side slopes of the valleys are very much steeper. Slopes of 600 and 700 feet per mile are numerous and in not a few cases slopes of 800 to 1000 feet[3] per mile are to be found in all regions of strong relief. Much steeper slopes than these are found in restricted areas. In fact one of the characteristic features in many parts of the Ozarks is the bluff or almost perpendicular cliff. In many cases these perpendicular cliffs form the most striking feature of the surface. High bluffs are particularly noticeable in Big Hill at Leo Rock and Fountain Bluff, along the lower course of the Big Muddy, bordering the Mississippi flood plain in the chert hill regions in western Union and northwestern Alexander counties. Other bluff regions, perhaps a little less noticeable, are to be seen along the Cache-Big Bay bottom lands that form the southern boundary of the Ozarks. Bluffs are also found along the Ohio river. There are various other situations where bluffs are to be seen bordering even some of the smaller streams in the interior of the Ozark region. Most of these bluffs are due to undercutting of streams, but faulting and weak rock layers underlying stronger rocks are also important causes.

Perhaps no better idea of the ruggedness of the Ozarks can be gained than from some quotations from geologists

3. Salisbury: Extract from Bull. No. 41, Ill. State Geological Survey, 1920, page 43.

who visited this region and left us their impressions of it. Dr. Salisbury, speaking of Hardin county alone, says, "In almost every direction from almost any point, hills and ridges alternate with valleys. Most of the valleys are 100 to 200 feet deep, but some of them are as much as 300 feet deep. Such relief alone, of course, does not make a mountainous country, but the slopes of many mountain regions are no steeper than many of the slopes of this country."[4]

Sixty-nine years ago Worthen, in a more picturesque way, gives us his impressions of the Ozarks: "In the spring of 1851, I undertook to make a reconnaissance of this ridge from the Big Muddy to the Ohio, through what was then an almost unbroken wilderness, and on foot and alone, with hammer in hand, I traversed this wild and picturesque region, reaching the Ohio in eight days after leaving the Big Muddy. The only signs of civilization to be met with then, in this region, was a log cabin now and then, occupied by some squatter family from east Tennessee or North Carolina, who imagined themselves entirely secure in this wilderness from the encroachments of a higher civilization."[5] Worthen's characterization of this region as "wild and picturesque" is not altogether out of place today when it is seen from the highest and most rugged parts of the Ozarks.

THE SOILS.

The soils of the Ozarks are by no means alike in all parts of this highland. The chief differences are largely due to these two causes: First, the ruggedness of the region and the character of the underlying rocks. To the types of soils here given, there are many local exceptions. In the western part of the Ozarks, underlaid by the Devonian rocks, the soils often have a large chert content and the surface is one of the most rugged in the entire highland. Here the soils are generally sterile, so much so that certain areas of very steep slopes were almost entirely destitute of timber even in the period of early settlement. The "Pine Hills" in western Union county is an example of this type of soil.

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4. Salisbury: Extract from Bull. No. 41, Ill. State Geological Survey, 1920, page 39.

5. Worthen: Geological Sur. of Ill., Vol. III, page 56.

The second region occupies the northern part of the Ozarks. This is the section where the resistant sandstones and conglomerates are immediately beneath the mantle rock. The soils are mainly a yellowish clay with a considerable intermixture of sand. The soils are light, warm, and well drained, but often of low fertility, and are particularly lacking in vegetable matter. In parts of this section the timber growth was never heavy. In the flat hill top parts of this section the soils are deeper and of higher fertility.

The third section includes the southern slopes of the Ozarks. In the limestone sections of this region the soils are the best of any part of the Ozark highland. These soils are of a reddish brown color and where the surface is not too rugged make fine fruit and truck lands.

While the soils of the Ozarks are generally poorer than the surrounding low-lands, still it must not be understood that they are not adapted to certain products, particularly when carefully tilled and under proper application of fertilizers. Many of these lands are the best fruit lands to be found anywhere in the state. Certain truck crops also do well in these same soils.

CLIMATE.

Since practically all of the higher hills of the Ozarks have an altitude of less than 1000 feet above mean sea level, their climate is practically the same as that of Carbondale, or any other towns near the base of these highlands. So the climatic data here given are from the records I have made as cooperative observer at the Carbondale station of the United States weather bureau. These data extend over a period of ten years and can be taken as giving a fair notion of the climate of this region.

From the Carbondale records it is clear that this southern section of Illinois is subject to great annual extremes of temperature. In a period of ten years, there were only two years that the temperature did not reach 100 degrees, or above; and in these two years only lacking one and two degrees respectively of reaching the hundred mark. The average for the ten years is almost exactly 100. There

were four years that the temperatures did not get as low as zero and with an average of almost exactly zero for coldest days. In 1912 and 1918 the temperature reached 24 degrees and 18 degrees below zero. These great extremes of temperature are due to the inland position of this section and to the fact that the low Central Plain of North America affords no obstruction to either the cold waves from the north or the hot winds from the south. The seriousness of these extremes is seen in the cold waves of 1912 and 1918 when the peach and other tender fruit trees of the Ozark region were seriously "winter killed."

The average mean July temperature for the last ten years is 80.04 degrees; the mean average for January temperature for the same period is 34.3 degrees. The average date of the first killing frost in the fall is October 25, and the average date of the last killing frost in the spring is April 9. This gives the average period free from frosts, six months and sixteen days. These are very important factors in determining the time of year that both fruits and vegetables can be placed on the city markets. But few summer apples reach the northern markets earlier than those from the Ozarks. The temperatures that the fruit and vegetable grower notices most, however, is the suddenness of temperature changes, particularly in the spring. A few warm days in March, or early April, often cause the fruit buds to burst into bloom; then comes a sudden cold wave which in one night will change a promising fruit crop to almost a failure. These spring freezes are the temperature changes that the fruit grower dreads most of all. Complete failures of the fruit crops are rare however, particularly of the hardier apples and small fruits. This is especially true in the higher parts of the Ozarks where the frost drainage is best and where the fruit industry is extensively and scientifically carried on. Even this spring of 1921 there is some fruit in the higher parts of the Ozarks, notwithstanding the fact that on March 24 and April 11 the temperatures were 24 degrees and 26 degrees. Some growers report from 20% to 75% of a crop for the hardier apples, and almost everywhere from 50% to 75% of a berry crop. The strawberries are about 50% and blackberries 75%.

The rainfall of the Ozark region is the heaviest in the state and ranges from 44 to 45 inches per year, for a period of ten years. For Carbondale the average has been nearly 44 inches. In some of the higher parts of the Ozarks it is a little higher, reaching 45 inches. The average distribution of the rainfall by months for a period of ten years is quite uniform, with a slight maximum in March, June, and November, and a little more pronounced minimum in August, September, and October. These figures refer to averages for a period of ten years. Individual years and months show quite different results. For instance in 1914 only .92 inches of rain fell in June and .35 inches fell in July, making in all, for a period of two critical months, only 1.27 inches. This rain was largely in slight showers and soon evaporated. The mean monthly temperature for July of that year was 83 degrees, or three degrees above the normal. Again in the year 1916, the rainfall was only .21 of an inch for July. Again this rain fell in slight showers and was soon evaporated because the mean July temperature of that year was 82 degrees, or two degrees above the normal. In both these years there was serious drouth in the two critical months of July and August, that did serious damage to all crops, particularly summer vegetables. Small fruits and even the apples and peaches were small, although the quality was otherwise good.

Thus the surface, soils, climate, and the composition of the rocks, particularly adapts the Ozarks to the production of fruits and vegetables, where railroad transportation is good. In the other sections stock raising and the production of timber should be the leading industries, while in certain restricted areas the mining of spar, kaolin, and silica have assumed considerable importance. But perhaps one of the newest and most needed mineral industries is limestone crushing. The limestone crushing industry has already assumed some importance in Union and Johnson counties. Union, Johnson, Pope and Hardin counties have abundant supplies of limestone, although their cherty composition is a discouraging feature in many localities.

THE ORCHARD BIRDS OF AN ILLINOIS SUMMER

PROF. S. A. FORBES,

CHIEF STATE NATURAL HISTORY SURVEY DIVISION,

URBANA, ILLINOIS

The above paper has been printed by the State as a separate bulletin. It may be obtained free by writing to Prof. Forbes. In view of the above it was deemed best to save on printing expense and not publish it in our Transactions.

UNDEVELOPED RESOURCES OF SOUTHERN ILLINOIS

R. B. MILLER, STATE FORESTER, URBANA

Situated as you are in the unglaciated region of Illinois, with a considerable area in each county unsuited by virtue of its slope for agricultural crops, I believe you should consider growing to a greater extent a crop which is suited primarily to rough hilly land—namely, the timber crop. A good photograph of many of your valleys will show that the proper division will be corn and truck in the valleys, wheat on land not too steep, orchards on the hillsides and woods at the top of the hills, all determined more or less on the basis of topography and slope. You have also bottomlands which are in drainage projects which have not yet been successfully drained, being subject to periodic overflow. Men at the lower ends of these ditches are often "flooded out." I contend that some of these bottomlands might grow a second crop of timber before being needed for agriculture, such rapidly growing species as cottonwood, gum, elm, maple, hackberry and sycamore, so called "softwoods" suitable to supply the veneer factories of this region.

Have you thought in connection with the planting of orchards, of the importance of a perpetual supply of timber for baskets, crates and hampers? The citrus growers of Florida use about 12,000,000 boxes annually for the shipment of their products, each box taking about five and a half feet of lumber, or say 65,000,000 board feet required. Truck growers of Florida use 13,000,000 more boxes, so that the expansion of the industry may some time be limited by a lack of material for crates and boxes in which to ship the crop.

You may reach the same situation in southern Illinois—in fact you have already felt the pinch in the rising prices of veneered material. Shooks for tomato crates and all forms of boxes for berries and melons are rapidly increasing in price, due in large measure to the exhaustion of the local supply of timber. Last fall apple barrels were selling for $1.50 each, a price which made their use almost prohibitive, shippers preferring to use baskets, a much less permanent

form of package. This means that you cannot ship the fruit so far as you did before and that in place of our getting a barrel of apples at the beginning of winter we have to be satisfied with a basket or two of the fruit. Some of the owners of these veneer mills have already told me that they import logs from Arkansas and Missouri and other states farther south and that the local supply of logs will not last over five years. Then they must move their mills to the south, nearer the timber, and you will be deprived not only of the cheaper product which you could buy at home but your town will lose a factory employing a great many laborers.

You are increasing each year the acreage of orchards and berries and melons, without thinking of where the boxes and crates are coming from to ship this produce to market. Why not devote some of this wet land to the growing of bottomland timber, keep your local mills running, give local people employment and assure the perpetuation of the fruit and truck-growing interests?

You have a great tie preserving plant right here in Carbondale, but only about one per cent. of the ties treated come from your own state or from regions near that plant. Why not look more carefully after the keeping of a supply of beech in these ravines of yours instead of being so anxious to make small patches of corn for a few years and then abandon the land? One man who is a competent judge says that Union County has the best supply of white and other oaks for railroad ties of any county in the state and yet these woods are allowed to burn over twice a year. I have been informed that large areas have burned over in Union County in the last two years. A year ago I saw six separate forest fires burning from the top of Bald Knob in Union County. It cannot be that there is no market for railroad ties because I know that last summer hackberry and maple ties, 7 by 9 inch face, were selling for $1.90 delivered, material which at one time would have been rejected. Methods of preservation with creosote or zinc chloride make this possible. Red oak and black oak can be similarly treated and made to give good service, while the more valuable white oak can be allowed to grow into saw timber, into ties, and

into piling and mine props. This is not altogether the fault of the people, although some are careless with fire, but because we have no means of enforcing fire laws. We need a good system of county fire wardens and deputy wardens to enforce the fire laws, along with an educational campaign on the value of fire protection in the woods.

Your coal mines need a large amount of timber for props, legs and rip-rap lumber, and could not run long without it. Some one has estimated that it takes three acres of timber to mine one acre of coal. Prices of mine timber are gradually soaring, yet I know of but one company which has looked ahead to a time when the supply may be exhausted. Care is needed by these coal companies in their cutting operations, of keeping fire out of young timber and perhaps in time of reforesting some of their waste lands.

Preservative treatment of cheaper species may need also to be taken up in the case of mine timbers, to save the slower growing oaks which are needed for the larger timbers.

Then there is the subject of idle and waste lands. You have a lot of yellow silt loam soil in southern Illinois, some counties, according to the Soil Survey of Illinois, having as much as 55% of this kind of land. Its loose character makes it very liable to erode and form gullies unless it is very carefully handled, to keep cover crops and improve its humus content. As the result of considering the land simply a mine, to take all out and put nothing back into the soil, thousands of acres of this kind of land are being rendered worthless by gullying. The Soil Survey says that some of it should never have been cleared but left in timber, both for the value of such a crop and to prevent the encroachment of these gullies into the more valuable lands. The question of what to do with this idle and waste land is a most pressing one but we believe that some way should be found of getting it back into timber. It is the 81 million acres of this kind of land in the United States, some of it burned over, that is causing our present shortage of timber in the United States.

These are some of your problems, then, as I see them—the need of better fire protection by the woodlot owner; the de-

votion of wet land to timber crops for the veneer and other industries until it is needed for farming; the keeping of the hills in timber both for its direct and indirect value; the stopping of timber devastation on land which never was or never will be suited to agriculture, thus increasing our acreage of waste land; and a respect on the part of large companies for the surface value of that land as a timber growing proposition, as well as the values which lie beneath the surface, realizing that it may yield a fair profit on the investment.

NOTE: This talk before the members of the Illinois Academy of Science and the people of Carbondale was made from lantern slides. Perhaps a more appropriate subject would have been "The Better Care of the Forest Resources of Southern Illinois and the Relation of Those Forests to the Industries and Economic Welfare of the Region."

R. B. MILLER, Survey Forester.

SLIDES SHOWN BY MR. MILLER

"UNDEVELOPED FOREST RESOURCES OF SOUTHERN ILLINOIS"

(FIRST SET) FOREST FIRES.

Slides showing fires burning from Bald Knob, Union County, March, 1920. Bad fires reported this last spring and most of the timber burned over every two years. Bald Knob, April 28th.

(SECOND SET) GULLYING LANDS.

Erosion, forming gullies, on yellow silt loam soil when this has a grade of *over 800 feet to the mile.* (Weller.) Keeping this covered with trees would prevent this waste.

(THIRD SET) THE VENEER INDUSTRY.

SHOWING MILLS AT JONESBORO AND COBDEN.

Shows that a supply of bottomland timber will always be needed and is vital to the fruit growing industry of the

region around Anna and Cobden. Increasing prices for tomato crates, berry boxes, hampers and baskets can be counteracted by growing elm, sycamore, gums, maples, etc., on land too wet for agriculture. No slack cooperage plants in the region but barrels shipped in cost $1.50 each when they might be made from veneered staves. Such wet lands might be used for forests and game refuges.

(FOURTH SET) TIE TREATING PLANTS.

Took up the subject of decay in timber and the use of preservatives, like creosote, to make cheap timbers as durable as white oak, thus saving the oak for saw timber, furniture, etc. Showed views in such plants as they have at Carbondale and Marion, where ties are treated by the pressure process. More ties should be grown locally instead of clearing so much bottomland timber.

(FIFTH SET) STATE PARK SITES.

A set of slides showing "Fern Cliff," a beautiful little spot near Goreville, Illinois. We need such places and should acquire them now before their pristine beauty is destroyed. The southern Ozarks abound with these spots for state parks which should be connected up with good roads for tourists, thus showing people what is in this part of the State. We need such places for rest and recreation and for their scientific and geologic interest. They will delight the botanist, the geologist, the lover of wild life and the recreationist, and be of lasting value to the State.

R. B. MILLER.

THE LORE OF THE SOUTHERN ILLINOIS OZARKS

CLARENCE BONNELL, HARRISBURG TOWNSHIP HIGH SCHOOL, HARRISBURG, ILLINOIS.

Almost every natural geographical division of every state has some of its history recorded in song or story. With the exception of Dickens' rather uncomplimentary reference to Cairo, and a brief story of the adventurous days of flat boats on the Ohio over a century ago in the story of *Virginia Rose* by E. R. Roe, little or nothing of legend or history concerning the Southern Illinois Ozarks has gotten into literature, either classical or otherwise. This is not for lack of material. The setting is fine and the wealth of story awaits only the imaginative mind.

The mound builders left their story in great monuments of earth in which are embedded earthenware water vessels, images, and trinkets. The Kincaid mounds in the bottom lands of southern Pope county, though scarcely touched except on the surface, have yielded an excellent collection of these. Numerous mounds, large and small, in the vicinity of Shawneetown, abound in pottery of fine design and often of large size. Two water pots found by Mike Robinson, of Shawneetown, but now owned by the Museum of the American Indian in New York, show good design. One holds one-half pint less than fourteen gallons, is fifty-nine inches in circumference and sixteen inches high. The other holds over eight gallons. Fragments of hundreds of others have been found scattered over a wide range, but so distributed as to indicate the vicinity of Shawneetown as near the center of this ancient pottery. One piece owned by Mr. Robinson is the arc of a circle of a vessel four or five feet in diameter at the mouth.

Excavations in Shawneetown reveal an ancient Indian village peopled by men who made a less perfect type of pottery. Skeletons and implements of war occur here and in more elevated places nearby in great profusion. Plumb bobs of hematite ore, as heavy as iron and of perfect proportion, a highly colored earthen-ware whistle, and charm stones of beautiful natural colors are among these. Every

neighborhood in the Illinois Ozarks has its collection of arrowheads, plows, axes, etc. Some of the many in Mr. Robinson's collection are as choice as will be found anywhere. An old gentleman of Shawneetown, who died a few years ago, had learned the art of shaping flints by pressure and had attained to a fair degree of skill in making arrowheads.

It has been suggested that the salt wells on the Saline river near Shawneetown may have been the reason for the centering of man's prehistoric activities here just as they became the Mecca for the early white man. But Indian remains widely distributed point back to other types of Indians. In southern Saline county, we find rock covered graves having stone lined walls.

When the white man came, the Indian population was considerable. Shawneetown gets its name from the Shawnees. Not many tales of Indian adventure are told, for these natives seem to have been given to works of peace, though they were "not too proud to fight," for they once met and defeated an encroaching tribe on a battleground in Williamson county.

The early man left no written record, except one. Magnificent natural features;—cliffs, caverns, natural bridges —none of these inspired him to write, with one exception. Near Ozark, at Gum Springs in Johnson county, the outline of a buffalo was cut and marked on a sandstone cliff. This figure is about one-third natural size. The outline and coloring of the lines resemble those in the supposed Aztec ruins near the petrified forests of Arizona. Mute evidence of a race of builders remains in remnants of the old stone forts—one near Stonefort in Saline county and another north of Makanda. These are protected in front by steep cliffs. On other sides of the semi-circular enclosures, a stone wall ten or twelve feet thick and eight or ten feet high gave protection from foes. Thus the white man found them, only to carry away the sandstone blocks to make chimneys, fire places, and foundations for himself. Today the fragments alone serve to mark the site of the walls. No clew remains to tell who made them or when.

If the grand old lady of stone, whose features stand out fifteen feet high from shoulder to crown looking from a high promontory of the Eagle Cliff fault line in Saline county, could only speak, she could tell wondrous tales of the men who trod the valleys below during the centuries since the mammoth mired in the muck of the Saline valley just beyond the southernmost extension of the glacial drift.

The early white explorers had objectives farther on. The trappers and hunters came and went. Of why and when the French built Fort Massac, little is known. George Rogers Clark came and went on and we think we know his trail. At least we have marked it with monuments.

The Ohio was the natural highway to the south and west and it was easy to go on past the forbidding rocky Ozarks. Yet there were fertile valleys and, in the valley of the Saline near Equality, there were salt wells. Man must have salt, so he came to get it and sometimes to stay. So Equality and Shawneetown date back to a time when Chicago was unthought of, Equality being the industrial center and Shawneetown the fort. All trails and all roads led by the salt wells. Negroes were brought to help in a later day. A bank was established at Shawneetown in 1816 and the building, now used as a residence, still stands.

Robbers and horse thieves came with settlements and industry. The famous cave at Cave in Rock in Hardin county was the scene of many a crime. Flat-boatmen mysteriously disappeared in this vicinity. The famous Ford gang and other gangs of outlaws and thieves were thought to have headquarters here. Following is a quotation from a letter written by Mrs. Kate Reynolds Sears of Whitewright, Texas, in answer to a request from me made a few years ago.

"Wm. McKay Robinson was the grandfather of the writer, her mother, Mary Thomas Robinson, having been his sixth child, and as a small child I have heard my grandmother, Mrs. Wm. M. Robinson, who was Rachel Hampton Thomas, tell the story to my listening ears.

"The uncle for whom my grandfather had been named had been beheaded and an aunt of my grandmother's, Aba-

gal Thomas, who was engaged to be married to Daniel Boone and was on her way at the time to meet and marry him, was taken by the Indians.

"In their desperation my great grandparents, with a friend and helper, bundled together what they could carry in a skiff; she, dear heart, was brave of heart but far from strong, as her infant, my grandfather (their eldest) was about four weeks old at the time; but knowing death was in their midst, yes, very near their home, lurked these savage fiends. After night had wrapt the earth in slumber, they carried their little bundles of clothes, bedding and food to a landing on the river and quietly stole away, to the unknown, but, as they hoped and believed, a place of safety.

"After much care and dodging (for they often felt they heard the paddle of the enemy's oar or a murmur of voices not far away) they landed at what is known as Cave in Rock, Illinois, on the Ohio river near Elizabethtown and after wandering around for a time (which seemed an age to the faint little mother) they espied what seemed to be a wash in a hillside or bank. Upon investigation it proved to be a cave and hearing something nearby they crept into this place not knowing what awaited them as they entered. I do not recall just how long the men remained, but only long enough to make the wife and babe as comfortable as they could under such circumstances and then they left them, promising to return in a few days at most."

Then follows an account of how this woman stayed for weeks in this cave living upon roots and berries, always in fear of discovery. Finally, in desperation, she found a wild turkey quill, tore a leaf from her Bible, wrote with blood a note and pinned it to her skirt which she hung on a bush outside to attract a passing boat. This plan succeeded and she was provided with food, but she refused to leave, so the boatmen left her to await the return of her husband who did not get back for more than two months.

Moonshiners had their stills in secluded places in the pioneer days. Stillhouse Hollow reminds us of those times, and the old stone for grinding the corn lies near. The first settlers were credulous people as are some of their later day

descendants. Lover's leaps, escapes from flood and beast, and unexplored caves with bottomless pits are still subjects of conversation in some sections. Only last week, I found a man who believed that the cave in Eagle Cliff in Saline county had never been explored. I with others have explored and mapped every passage in it, yet once (and only once) when I attempted to refute erroneous statements about this cavern in a local newspaper, I brought down the wrath of an unbeliever, who in his reply said: "We 'over creekers' (country people) are somewhat envious when a party of teachers and professors, who were reared in the city, come to explore, and naturally feel that they expect to accomplish more with their brains than we with experience." This same writer goes on to reiterate his statements that this cavern has bottomless pits and unexplored passages and that it connects with the cave at Cave in Rock, some twenty-five miles away. His attitude illustrates well that of many who cling tenaciously to the traditions of the past. Diggings in the floor of sandstone caves and midnight desecration of old graves point back to the time when treasure was unsafe. Scarcely any tradition has no basis of fact. Much real history otherwise unrecorded can yet be gleaned from the mouth to mouth stories of the older generation still living. A widespread but dim remembrance of the great New Madrid earthquake of 1911-12 still lingers with some of these people. That all of southern Illinois was violently shaken then cannot be questioned. A descendant of a girl named Elizabeth ———— for whom Elizabethtown is said to have been named, tells how the earth was shaken there soon after the party of settlers came. An original record, written by one who had been in Illinois in January, 1912, gives the following vivid picture of conditions at that time. The spelling and punctuation are given verbatim:

Sinsenatte State of Ohio

April the 12 - 1812

Dear Brother I now set down to right to you to let you no that I am well hoping that when these lines cum to your view they will find you enjoying the same blessing I will further inform you that I have left the Miss-

isippee through the goodness of God. Altho there is not many of our new England peopple that were able to do that for they had to stay whether they liked the country or not for the people of this country are so kind that they have given the most part of our Yankies a small piece of groun enugh to lay down upon where I left them laying

after I rote before Mr Stevens and myself undertook the bilding of a mill which we were to work uppon when Mr. Stephens dyed after that I continued to carry the work on myself until I was taken sick myself

then I was obliged to quit it & I lay sick myself with the fever & aguer about Eight months in which time I got reduced some so I was so for about four months that I could not tell whether they meant to kill me or not but finding me so tuf they quit the notion and so I got of

I would mention a little of the situation of the Misippee Country at the present time which is very bad ever since the battle that we had with the Indians at the Wabash which I suppose that you have had an account in the newspapers the Indians have bin very troblison They have kild a grate many this spring

But what is much more terrible than the Indians on the sixteenth of December We had a Grate Earth Quake which the Shook the Earth to the senter And Shaking Still continued til I left Kaskaskia which was the twenty first day of Febuary. It has damaged and thrown down almost All the houses down in that county and in many plases the earth has Craked open for a quarter of a mild in length and throwne out vast boddies of sand and water and in several plases there is large tracts of country that is all sunk down and overflowed with water The people are moving out of this country faster than they ever moved into it

As time fails me I must right short I wish you to give my sincere respects to that good old mother of mine and also to all of our family as well as yours. Give respects to my young friend in particular to Zebeus tel them all that I want to see them very much but I cant tell when I shall do it Right to me without fail As soon as you receive this write your letter to Maryette in the State of Ohio for I

think I shal be there in about three weeks and you must not fail of Righting to me for I have not recvd but three letters since I left home and I think you have all forgot me or you would right oftener. Right to me if you have herd anything from my father since I cum away and furthermore let me know if my wife is married or not & so I must conclud by stiling myself your Brother &c

A. DILLINGHAM.

Stories come to me of an "Underground Railroad" station about four miles southeast of Equality in Gallatin county. Upon a hilltop, stands a large two story frame house conspicuous for its many large windows. It is a plain rectangular block of a house, with a well pitched roof having a deck something like twelve feet wide running the entire length. Just under the edge of the deck there are windows corresponding to the ventilators of a railway car. The gables have large windows. The attic is said to have been reached by a narrow stairway. Along each side of the attic hall just under the sloping part of the roof there are bunks arranged, bunks just as the beds are situated in a Pullman car. One man relates that apparatus resembling stocks were seen in the rubbish of this attic. The story is that it was built between 1838 and 1844 and was owned by Johnny Crenshaw. Some metal ornaments on the house are said to have come from England. Instead of this being an "underground" station for escaping slaves, so the story goes, this one was once used by a band operating as the automobile thieves of today. A free negro or one escaping by flight, if found by this gang, was overpowered and conveyed by night under guard from farther north to this station. Another night journey took him to and across the Ohio river where his word was not accepted in court and where undisputed possession was evidence of ownership.

The price that negroes brought in those days was great enough to justify the risk taken by the captors. Some who have owned this house and lived in it tell this story as true. Others who were children in that day and lived only a few miles away claim no knowledge of such use of the property.

This is explained on the ground that great secrecy was maintained by the owners. True or untrue, here is a story to stir the imagination.

The magic change from water mill and spinning wheel to the modern hum of motors and the busy life in coal and spar mine, all coming within a generation, has so woven the realities of the present with the uncertainties of the past that the poet or writer of fiction could create a classic from the setting afforded by the facts and hearsay, recorded and unrecorded, in Southern Illinois.

Papers on Biology and Agriculture

SOME PLANTS OF THE BOIS FORT INDIAN RESERVATION AND VICINITY IN MINNESOTA

PROF. ALBERT B. REAGAN, KAYENTA, ARIZONA

The Bois Fort Indian Reservation, containing 107,519.43 acres, is situated 140 miles northwest of Duluth, Minnesota, and 38 miles south of Fort Frances, Ontario. It surrounds a beautiful sheet of shallow water of three-fourths of a township in area, known as Nett Lake. Its land is variable in condition of soil and possible fertility. One-half of it is swamp and is known to the Indians as "muskeg" land. The non-swamp eastern part is composed of rock ridges of the Couchiching formation, flanked with clay land covered with pine and hardwood forest trees. The western part, which is not covered with swamp, is a sandy region. Nett Lake and its tributary streams occupy the east-central part of the reservation and the Little Fork and Nett rivers cross it. The swamp areas are in the jungle state. The dry land is still heavily timbered where not already logged, while wild rice grows in the shallow lake so that it looks like a vast wheat field in summer. As is seen, the region is practically in the virgin state. The same might be said of the region extending southward and eastward to Duluth and Lake Superior and northward to the Arctic Ocean, much of which is composed of lakes and swamps.

The tribal timber of the reservation was cut prior to 1909 when the writer became agent of the reserve, and the individual Indian timber is being logged off now (1921). The individual pine timber was estimated at 17,000,000 feet B. M. and the pulp wood into millions of cords.

Below are some of the plants of the region that were identified by the writer as time would permit while he was in charge of the agency there.

RANUNCULACEAE (CROWFOOT FAMILY.)

Genus *Ranunculus*.

Ranunculus affinis, R. Br. common.
Ranunculus affinis, var. validus, Gray. Often seen.

Genus *Caltha*, L. Marsh Marigold.

Caltha palustris, L. Common.

Genus *Aquilegia*, Tourn. Columbine.

Aquilegia canadensis, L. Wild Columbine. Found everywhere.

SARRACENIACEAE. PITCHER FAMILY.

Genus *Sarracenia*, Tourn. Side-saddle Flower.

Sarracenia purpurea, L. Side-saddle Flower, Pitcher Plant, Huntsman's Cup. Quite common.

PAPAVERACEAE. POPPY FAMILY.

Genus *Sanguinaria*, Dill. Blood-root.

Sanguinaria canadensis, L. A very common Indian medicine. It is also used in the jugglery performances of the medicine men. It blooms in April.

FUMARIACEAE. FUMITORY FAMILY.

Genus *Dicentra*, Borkh. Dutchman's Breeches.

Dicentra cucullaria, DC. Dutchman's Breeches. Very common.

CRUCIFERAE. MUSTARD FAMILY.

Genus *Lepidium*, Tourn. Pepperwort. Peppergrass.

Lepidium virginicum, L. Wild Peppergrass. Abundant everywhere. Much used by the Indians.

Genus *Sisymbrium*, Tourn. Hedge Mustard.

Sisymbrium officinale, Scop.

Genus *Brassica*, Tourn.

Brassica campestris, L. Escaped from cultivation.

VIOLACEAE. VIOLET FAMILY.

Genus *Viola*, Tourn. Violet. Heart's Ease.

Viola sagittata, Ait. Arrow-leaved Violet. Common.

Viola palustris, var. *Nettlakeis*, n. var. Resembles *V. palustris*, but has a long, slender spur, slightly thickened at the end; spur almost as long as the beardless violets.

Viola rotundifolia, Michx. Round-Leafed Violet. Quite common.

Viola pubescens, Ait. Downy Yellow Violet. Very common.

Viola pubescens, var. *Nettlakeis*. All petals veined with purple. Seen May 19, at Little Fork R.

PORTULACACEAE. PURSLANE FAMILY.

Genus *Portulaca*, Tourn. Purslane.

Portulaca Oleracea, L. Common Purslane. Very common.

TILIACEAE. LINDEN FAMILY.

Genus *Tilia*, Tourn. Linden. Basswood.

Tilia americana, L. Basswood. Very common, trees unusually large.*

*Thread, twine, cord and rope are usually made from basswood for many uses now and wholly so in the old times, unless made from the sinew of the moose and deer or from rawhide.

The basswood tree of this region, when in bloom, is a beautiful tree.

As a further note on the use of basswood: In preparing basswood thread, the inner bark of young sprouts is removed in sheets and boiled in water to which a large quantity of lye from wood ashes has been added. This softens the fiber and permits it to be manipulated without breaking. The unoccupied squaws then employ their time in pulling the bark into shreds and twisting same into twine and the latter into ropes as needed. This twine is the sewing material used in weaving mats, erecting bark houses and tepees and for almost all other household purposes. When put away for future use it is hung up in hanks.

GERANIACEAE. GERANIUM FAMILY.

Genus *Impatiens*, L. Balsam. Jewel-weed.

Impatiens pallida, Nutt. Pale Touch-Me-Not. Common.

CELASTRACEAE. STAFF-TREE FAMILY.

Genus *Celastrus*, L. Staff-tree. Shrubby Bitter-Sweet.

Celastrus scandins, L. Wax-Work, Climbing Bitter-Sweet.

SAPINDACEAE. SOAPBERRY FAMILY.

Genus *Acer*, Tourn. Maple.

Acer pennsylvanicum, L. Striped Maple, a common tree.

Acer spicatum, Lam. Mountain Maple.

Acer saccharinum, Wang. Sugar or Rock Maple.**

Acer saccharinum, var. *nigrum*, Torr & Gray. Black Sugar Maple.**

**The sugar maple is a common tree on the reservation. It grows in groves. The trees are scarred by repeated tappings, causing each to be considerably enlarged in the part of the trunk that is subject to the tapping. Many tons of sugar are annually made by the Bois Fort Indians.

The sugar-making season comes when the first crow appears, usually about the middle of March, while there is yet snow on the ground. The medicine men give orders and the sugar-making holiday is begun; every one goes to his respective maple grove, which is the place of the sugar-making for that respective family and claimed by right of descent, through the mother's totem.

The first thing on arriving on the ground is to erect the temporary tepees. These are the usual conical frame made of poles leaning together at the top and spreading to the ground all around, and covered with bark or canvas. There is one entrance door and the smoke from the central fire escapes at the top among the loosely fastened poles. Racks are then set up, on which to hang the pots for boiling the syrup, enclosed often in enlarged, elongated bark tepees.

The next work is the preparing of sap dishes and sap buckets.

Quantities of bark is peeled off from the nearby white birch trees; pieces of the bark are cut and folded into sap dishes and pans, each measuring eight to twelve inches in width, eighteen inches in length, and about six inches in depth. The ends are carefully folded and stitched along the edge with basswood fiber, so that it will retain its shape. Several hundred of these dishes are made by each family. Sap buckets are then made from birch bark. These are cut and folded at the corners so as to avoid breaking the bark. The folds are then seamed with pine resin. When completed these buckets are elongated in shape, are supplied with a carrying bale, and are made deep enough to hold one or two gallons. The average bucket measures about six inches across the top, which is round, and eight to nine inches across the elongated bottom; the depth is about nine inches. To strengthen the pail the top and rim are held in place by means of thin strips of wood neatly stitched fast with basswood fiber. Mococks or boxes for containing the sugar product are made in the same way and are much the same shape.

When the preparations are completed, the sap gathering commences. One (or more) small oblique gash is cut in each sugar tree so as to take out the bark and about an inch of the sap wood. Down this gash the sap runs to the bottom and trickles downward along the side of the tree. Just below the lower point of the gash a horizontal cut is made in the bark and a downward sloping chip is driven into this cut so that the sap from the cut above runs over it and drips from the end into a sap dish set under the chip to catch the drippings. Twice a day these dishes are emptied into sap buckets and the sap carried to the tepee to be boiled into sugar.

The sap is boiled in cans and kettles within the large wigwams or outside under the racks previously mentioned; they have a tradition that before they could get iron kettles, their ancestors used to make kettles of clay with which they boiled sap. As soon as one kettle full is converted into sugar, another kettle full of sap is hung over the fire; as many kettles are used in this process as the family can obtain.

When the syrup begins to granulate, it is poured into wooden troughs where it is stirred and the granulating process completed. Much of the syrup just in the act of granulating is thrown on snow to cool rapidly, forming sugar wax, which is a good substitute for our candy.

Sugar cakes are also formed by pouring the syrup into sauce dishes, small cake dishes and the like, when just in the act of granulating. These are remelted into syrup when needed. Much of the maple sugar is now sold to the whites in cake form, the granulated product being put into mococks for future use.

Besides sugar being obtained from the sugar tree, many things are made from the hard wood of this tree. One of these is the bowl used in the dice bowl game. This is a large, rather shallow, symmetrical, nicely finished, hemispherical bowl. It is made from a large, round nodule of maple root, and is consequently a rare and expensive article for its size. It is fashioned solely with the aid of an ax and a knife. A specimen at hand measures nine inches in diameter at the top and is two inches in depth. It is nearly one inch in thickness at the bottom, but gradually tapers to about one-fourth of an inch at the rim.

ANACARDIACEAE. CASHEW FAMILY.

Genus *Rhus*, L. Sumach.

Rhus glabra, L. Dwarf Sumach.
Rhus copallina, L. Dwarf Sumach.
Rhus canadensis, Marsh.
Rhus aromatica, Ait.

The Sumach is a very common shrub throughout the region. Its bark and berries are much used in the medicine ceremonies of the aborigines.

Polygala senega, L. Seneca Sankeroot. It is used as a medicine.*

*Of the family Polygalaceae; Milkwort Family.

LEGUMINOSAE. PULSE FAMILY.

Genus *Baptisia*, Vent. False Indigo.

Baptisia tinctoria, R. B. Wild Indigo. Very common. This plant was used much in native coloring and as medicine.

Genus *Lathyrus*, Tourn. Vetching. Everlasting Pea.

Lathyrus ochroleucus, Hook. Quite common.
Lathyrus palustris, L. (?)

ROSACEAE. ROSE FAMILY.

Genus *Prunus*, Tourn. Plum, Cherry, Etc.

Prunus americana, Marshall. Wild Yellow or Red Plum.
Prunus pennsylvanica, L. f. Var. Nettlakea. Pin Cherry. Very common.
Prunus virginiana, L. Choke Cherry.
Prunus serotina, Ehrh. Wild Black Cherry.
Prunus demissa, Walp.

The plums and cherries above are very plentiful in the Bois Fort region and are quite extensively used as food. The fruit is eaten fresh and also dried for winter use. When needed for use after being dried, the berry, seed and all, are often crushed and ground up and the whole used as a sort of flour in making soups.

Genus *Rubus*, Tourn. Bramble.

Rubus strigosus, Michx. Wild Red Raspberry. A very abundant plant. Its fruit is extensively used by the natives as a food. The fruit is both eaten fresh and dried for winter use.

Genus *Fragaria*, Tourn. Strawberry.

Fragaria virginiana illinoensis, Gray. Seen near Flat Rock. Strawberries are much used as food by the Indians.

Genus *Rosa*, Tourn. Rose.

Rosa sayi, Schwein. (?)
Rosa lucida, L. Common. The buds are occasionally eaten. The root and bark are also sometimes used as medicine.

Genus *Pyrus*, L. Pear. Apple.

Pyrus coronaria, L. American Crab-apple. Quite common.
Pyrus americana, D. C. American Mountain Ash.*
Pyrus sambucifolia, Cham. & Schlecht. Occasionally seen.

*When steamed the ash is bent into any form desired by the Ojibwa.

Genus *Crataegus*, L. Hawthorn. White Thorn.

Crataegus coccinea, L. Quite common.

Genus *Amelanchier*, Medic. June-berry.

Amelanchier canadensis, var. *oblongifolia*, Torr. & Gray. Shad-bush. Service-berry. Quite common.

SAXIFRAGACEAE. SAXIFRAGE FAMILY.

Genus *Ribes*, L. Currants. Gooseberry.

Ribes gracile, Michx. Gooseberry.
Ribes oxyacanthoides, L. Common.
Ribes hudsonianum, Richards. Currant. Common.
Ribes floridum, L'Her. Black Wild Currant.
Ribes rubrum, L., var. subglandulosum, Maxim. Red Currant. Common.

The currants and gooseberries are used as food by the Indians, both fresh and dried. The roots and bark are also much used as medicine.

ONAGRACEAE. EVENING-PRIMROSE FAMILY.

Genus *Oenothera*, L. Evening Primrose.

Oenothera rhombipetala, Nutt. Common. In bloom June 30.

CUCURBITACEAE. GOURD FAMILY.

Genus *Sicyos*, L. One-seeded Bur-Cucumber.

Sicyos angulatus, L. Common everywhere, becoming a pest in the fields.

UMBELLIFERAE. PARSLEY FAMILY.

Genus *Conioselinum*, Fisch. Hemlock-Parsley.

Conioselinum canadense, Torr. & Gray. Common.

Genus *Heracleum*, L. Cow-Parsnip.

Heracleum lanatum, Michx. Common. Much used as greens.

Genus *Aralia*, Tourn. Ginsang. Wild Sarsaparilla.

Aralia racemosa, L. Spikenard. Common. Used as medicine by the Indians. One old medicine man cultivates a patch of this plant.

CORNACEAE. DOGWOOD FAMILY.

Genus *Cornus*, Tourn. Cornel. Dogwood.

Cornus sericea, L. Silky Cornel. Kinnikinnik. A Chippewa medicine. Also smoked and much used in the various ceremonies of the Northern Indians. Indians also get drunk on the smoke of the plant and the other kinnikinnik, which will be described later.
Cornus stolonifera, Michx. Red-Osier Dogwood.

CAPRIFOLIACEAE. HONEYSUCKLE FAMILY.

Genus *Sambucus*, Tourn. Elder.

Sambucus racemosa, L. Red-berried Elder. Common. Used as food.

Genus *Virburnum*, L. Arrow-wood. Laurestinus.

Viburnum opulus, L. Cranberry Tree. High Cranberry Bush. Quite common. The acid fruit is used much in making jelly by the whites. The Indians use the fruit also.

RUBIACEAE. MADDER FAMILY.

Genus *Mitchella*, L. Partridge-Berry.

Mitchella repens, L. Common. Much used by the Indians.

COMPOSITAE. COMPOSITE FAMILY.

Genus *Bidens*, L. Bur-Marigold.

Bidens bipinnata, L. Spanish Needles. Too plentiful.

Genus *Erechtites*, Raf. Fireweed.

Erechtites hieracifolia, Raf. Fireweed. A very common and abundant weed in burned areas.

Genus *Arctium*. Burdock.

Arctium lappa, L. Common. Probably escaped or introduced with seed.

Genus *Cnicus*, Tourn. Common or Plumed Thistle.

Cnicus arvensis, Hoffm. Canada Thistle. Too plentiful.

Genus *Taraxacum*, Haller. Dandelion.

Taraxacum officinale, Weber. Common Dandelion. Common.

(ERICACEAE) MONOTROPEAE. INDIAN-PIPE FAMILY.

Genus *Gaylussacia*, HBK. Huckleberry.

Gaylussacia resinosa, Torr. & Gray. Black Huckleberry. Used as a food.

Genus *Vaccinium*. Blueberry. Bilberry. Cranberry.

Vaccinium pennsylvanicum, Lam. Dwarf Blueberry.

Vaccinium Canadense, Kalm. Blueberry.*

*The blueberries are abundant. Every hill and open space is covered with them. Blueberry harvest is a great time for the Indians. They go far and near and gather them to sell at so much a box. Car loads are gathered and sold to the nearby stores for shipment, buyers often being sent from St. Paul, Minneapolis, Duluth and the nearby towns to purchase them. The natives also now can them white man's way. Many are eaten fresh and tons of them dried on racks in the sun for winter use. These berries are the most abundant wild fruit of the region.

Vaccinium oxycoccus, L. Small Cranberry.

Vaccinium macrocarpon, Ait. Large or American Cranberry.

Cranberries are very plentiful in the swamp regions and are quite an article of food. Many bushels are also sold by the Indians each year.

Genus *Arctostaphylos*, Adams. Bearberry.

Arctostaphylos una-ursi, Spreng. Bearberry. The leaves of this plant are smoked, causing intoxication. The plant is much used in the medicine ceremonies.

Genus *Epigaea*, L. Ground Laurel. Trailing Arbutus.

Epigaea repens, L. Trailing Arbutus. Seen on burning near Thompson's homestead.

Genus *Gaultheria*, Kalm. Aromatic Wintergreen.

Gaultheria procumbens, L. Creeping Wintergreen. Common on sand ridges near Thompson's homestead. The "berry" was much used as a food by the Ojibwa.

POLEMONIACEAE. POLEMONIUM FAMILY.

Genus *Polemonium*, Tourn. Greek Valerian.

Polemonium reptans, L. Common.

Polemonium caeruleum, L. Jacob's Ladder. Common.

BORRAGINACEAE. BORAGE FAMILY.

Genus *Echinospermum*, Lehm. Stockweed.

Echinospermum floribundum, Lehm. Beggar lice. A pest everywhere.

Genus *Mertensia*, Roth. Lungwort.

Mertensia paniculata, Don. Blue Bells. Quite common.

SOLANACEAE. NIGHTSHADE FAMILY.

Genus *Solanum*, Tourn. Nightshade.

Solanum nigrum, L. Common Nightshade. Common. Used in the medicine ceremonies by the Indians.

LABIATE. MINT FAMILY.

Genus *Mentha*, Tourn. Mint.

Mentha canadensis, L. Wild Mint. Quite common.

Genus *Stachys*, Tourn. Hedge-Nettle.

Stachys palustris, L. Nettle. Common.

PLANTAGINACEAE. PLANTAIN FAMILY.

Genus *Plantago*, Tourn. Plantain.

Plantago major.. Common Plantain. Not common.

CHENOPODIACEAE. GOOSEFOOT FAMILY.

Genus *Chenopodium*, Tourn. Pigweed.

Chenopodium album, L. Pigweed. Common.

POLYGONACEAE. BUCKWHEAT FAMILY.

Genus *Rumex*, L. Dock. Sorrel.

Rumex altissimus, Wood. Pale Dock. Common.

Genus *Polygonum*, Tourn. Knotweed.

Polygonum dumetorum, var. *scandens*, Gray. Climbing False Buckwheat.

THYMELAEACEAE. MEZEREUM FAMILY.

Genus *Dirca*, L. Leatherwood. Moosewood.

Dirca palustris, L. Moosewood. Used for withes by Indians.

URTICACEAE. NETTLE FAMILY.

Genus *Ulmus*, L. Elm.

Ulmus fulva, Michx. Slippery or Red Elm. Rare.

Ulmus americana, L. American or White Elm. Quite common, and a large tree.

CUPULIFERAE. OAK FAMILY.

Genus *Betula*, Tourn. Birch.

Betula lenta, L. Cherry Birch; Sweet or Black Birch.

Betula lutea, Michx. f. Yellow or Gray Birch.

Betula papyrifera, Marshall. Paper or Canoe Birch.

The birches and poplars are the most numerous trees of the reservation and from an Indian point of view are among the most valuable, especially the birches, for from them their birch bark utensils are made.*

*Birch Bark Utensils: The bark of the white (paper) birch was used in the old times and is still used for making various convenient small vessels, pails, and trays. When made for permanent use, the parts of the article are firmly sewed together with basswood twine and the edges counter wrapped with the same material.

If the article is wished to be made water tight, its seams are sealed with pitch. The following are some of the useful birch bark articles used by the Bois Fort Indians: Mococks (in which wild rice and maple sugar are stored); dishes; sap dishes (used in catching maple sap); rice baskets; buckets; trays and winnowing dishes (used when separating the chaff from the rice.)

The CANOE is also made from birch bark. The Ojibwa reached his zenith in manufacture when he made the canoe. It is undoubtedly the most beautiful and light model of all the water crafts ever invented. The frame work is made of white cedar or some other light, durable wood; the ribs are thinned to the right thickness with a drawing knife, and when the desired number are obtained, they are steamed, after which they are curved according to the part of the canoe which they are intended to brace. The tops of the ribs are then securely tied to the top plate-piece of the canoe with roots of tamarack, or some other tough tying material; this frame is then placed in a sort of rack and the birch bark put on it so ingeniously and so well sewed together and the seams so well closed with pitch, that the finished canoe is water tight and rides on the water like a cork.

Genus *Corylus*, Tourn. Hazel-nut.

Corylus rostrata, Ait. Beaked Hazel-nut. Very common and much used as food by the natives.

Genus *Carpinus*, L. Hornbeam. Iron-wood.

Carpinus caroliniana, Walter? American Hornbeam. Blue or Water Beech.

Genus *Quercus*, L. Oak.

Quercus rubra, L. Red Oak. Common. There are other oaks in the region, but were not identified by the writer, though often seen.

SALCACEAE. WILLOW FAMILY.

Genix *Salix*, Tourn. Willow. Osier.

Salix candida, Willd. Sage or Hoary Willow. Common.

Salix balsamifera, Barratt. Common.

Genus *Populus*, Poplar. Aspen.

Populus tremuloides, Michx. American Aspen. Very common in loamy sections, but not so common as the poplars.

Populus grandidentata, Michx. Occasionally seen.

Populus balsamifera, L. Balsam Poplar. Very common in the loamy regions.

Populus monilifera, Ait. Cotton Wood. Common along the streams, and occasionally seen inland.

There are millions of cords of pulp wood of the Populus species above on the reservation.

CONIFERAE. PINE FAMILY.

Genus *Pinus*, Tourn. Pine.

Pinus strobus, L. White Pine.

Pinus banksiana, Lambert. Northern Scrub Pine.

Pinus resinosa, Ait. Red Pine.

The pine still standing on the reservation in the fall of 1920 was estimated at 17,000,000 feet B. M.

Genus *Picea*, Link. Spruce.

Picea nigra, Link. Black Spruce.

Picea alba, Link. White Spruce.

Genus *Abies*, Link. Fir.

Abies balsamea, Miller. Balsam or Balm-of-Gilead Fir. Common.

Genus *Larix*, Tourn. Larch.

Larix americana, Michx. Tamarack. Practically the whole region just at the swamp line when in the "dry" peaty state is covered with tamarack forest from the Nett Lake region on northward into Canada as far as the writer has been in that dominion. The Ojibwa use the roots of this tree to sew their canoes and also in the strong upper wrappings over the edges of same.

Genus *Juniperus*, L. Juniper.

Juniperus sabina, L., var. *procumbens*, Pursh. Found in the swampy areas.

Juniperus virginiana, L. Red Cedar. Found bordering the streams and inland, but usually on higher ground than *J. procumbens* above.*

*It is estimated that there are cedar post timber enough in the region to furnish a billion posts. The pulp wood and the cedar posts are now being floated down the various streams to Canada where the pulp wood is made into paper at the International Falls pulp mills, said to be the largest in the world. There, also, the posts are loaded onto cars and shipped to the States for fencing. Cutting posts and pulp wood is a great industry in this section and will be for many years to come.

BROMELIACEAE. PINEAPPLE FAMILY.

Genus *Cypripedium*. Lady's Slipper.

Cypripedium pubescens, Willd. Large Yellow Lady's Slipper. Common.

LILACEAE. LILLY FAMILY.

Genus *Maianthemum*, Wigg.

Maianthemum canadense, Desf. A common plant.

Genus *Uvularia*, L. Bellwort.

Uvularia perfoliata, L. Occasionally seen.

Uvularia grandiflora, Smith. Seen in the rich woods.

JUNCACEAE. RUSH FAMILY.

Genus *Juncus*, Tourn. Rush. Bog-rush.

Juncus stygius, L. Common around lakes. This plant is used in weaving mats. *It also holds quite a place in the myths of the Ojibwa.

TYPHACEAE. CAT-TAIL FAMILY.

Genus *Typha*, Tourn. Cat-tail.

Typha latifolia, L. Common Cat-tail. The flags of this plant are used much in mat weaving.*

*The Bois Fort Indians have several varieties of mats. These are made from rushes, from cedar bark and from the broad blades of the cat-tail flag. Some of the mats are woven coarse, others fine; they are from six to fifteen feet in length and about a yard in width, and are used for bedding and house and floor coverings.

ARACEAE. ARUM FAMILY.

Genus *Arisaema*, Martinus. Indian Turnip. Dragon Arum.

Arisaema triphyllum, Torr. Indian Turnip. Jack in the Pulpit. A very common plant and much used as medicine by the natives.

LYCOPODIACEAE. CLUB MOSS FAMILY.

Genus *Lycopodium*, L. Club-Moss.

Lycopodium lucidulum, Michx. Common.

Lycopodium selago, L. Very common.

The mosses are abundant in this region, many species, no doubt, being represented. The trees hang with it and the swampy areas are covered with it. Moreover the peat of the region is composed for the most part of moss, rushes and flags.*

*The following plants were seen but not identified:

Reindeer Moss (Tripe Roche.) The writer was told that this moss was eaten by the Indians in the old times, also that moose feed on it.

Wuab-es-see-pin (Ojibwa name.) This plant resembles the potato. It grows in wet ground. It is mealy when boiled. It is even now occasionally eaten by the natives who eat it with a relish.

Stitch-auc-waub-es-see-pin (Ojibwa name.) This is a similar plant to the last named above. It is found throughout the region. It is used as a food by the natives, being boiled.

GRAMINEAE. GRASS FAMILY.

Genus *Setaria*, Beauv. Bristly Foxtail Grass.

Setaria glauca, Beauv. A common pest.

Genus *Zizania*, Gronov. Water or Indian Rice.

Zizania aquatica, L. Indian Rice. Water Oats. This is the most important wild food plant in the region. It grows along the swampy borders of streams and in the shallow water of the numerous small lakes of the region from the Great Lakes on westward throughout Minnesota to the Red River valley in that state and on northward into Canada. It belongs to the grass family. It is an annual; flowers monoecious; the staminate and pistillate are both in 1-flowered spikelets in the same panicle. Glumes 2, substended by a small cartilaginous ring, herbaceous-membranaceous, convex, awnless in the sterile, the lower one tipped with a straight awn in the fertile spikelets. Palet, none. Stamens 6. Stigmas pencil-form. A large reed-like water-grass. Spikelets jointed upon the club-shaped pedicels, very deciduous. Culms 3 to 9 feet high; leaves flat, 2 to 4 feet long (and lie flat on the water when they first emerge; later they stand erect and finally decline at the tips), linear lanceolate; lower branches are of the ample pyramidal panicle staminate, spreading; the upper erect, pistillate; lower glume long awned, rough; styles distinct; grain linear, slender, 6" long.

This rice is one of the leading articles of food of the aborigines and was such in the old times.*

*The writer became acquainted with this plant at Nett Lake, Minnesota, where he had charge of the Bois Fort Indian Reservation as Superintendent and Special Disbursing Agent from 1909 to 1914. Nett Lake, the lake that bears that name, covers three-fourths of a township in area and is in the shape of a great lobster's paw with the claws pointing eastward, the major claw being the northern member. It is a very shallow lake, the greater part being less than four feet in depth. In this the wild rice grows in such quantities that the lake looks like a great barley field.

The rice does not ripen all at once, so can not be cut like a field of barley. But as the grains drop from the stalk very easily when ripe, it can be pounded off into a canoe with a stick and the green grain still left to ripen.

The rice begins to ripen the latter part of August. The Indians then have a secret ceremony and much powowing. Then the chief medicine man gives permission for them to go out and gather rice.

With canoes, the Indians go among the rice and beat the heads over the canoe with short clubs. This they keep up till they have a canoe full of rice. Then they go to the village with it.

At the village, the rice, which is just past the milk stage when gathered, is parched and scorched in a large iron kettle inclined over the fire so that a squaw can stir it to keep it from burning. By this scorching process the hulls are all burned from the kernels, or are so dried and charred that they can be loosened and removed by the next process.

As soon as the scorched rice is removed from the kettle and is cold enough to handle, it is placed in a cylindrical hole in the ground that has been lined with cement or marl from the lake. Then the Indian man of the house gets into this hole and tramps the hulls off with his feet. After the tramping is completed, the chaff, dust and ashes are winnowed from the rice by the women. The product is then sacked and is ready for sale as breakfast food. It sells at not less than 30 cents per pound at the village, and as high as 50 cents in the neighboring cities.

This rice makes good gem cakes. It is also used to stuff ducks and other fowls when preparing them for dinners. Orders have come from as far as Salt Lake City for rice for making dressing for ducks for Thanksgiving dinners.

In preparing it as breakfast food, it is prepared and cooked the same as white rice and can be cooked in as many different ways. The preferable way, however, is to take a cupful of the rice and pour a cupful of boiling water on it at bedtime and then cover it up so as to keep the steam in and let it set till morning, then put it on the stove and evaporate the remaining water. It is then puffed-rice, and is delicious with sugar and cream.

The Ojibwa sometimes boil the excrements of the rabbit with the rice "to season it" and are said to esteem it as a luxury. To make that dish still more palatable, and one of the highest epicurean dishes, they occasionally take a partridge, pick off the feathers, and without any further dressing except pounding it to the consistency of jelly, throw it into the rice, and boil it in that condition.

Genus *Hordeum*, Tourn. Barley.

Hordeum jubatum, L. Squirrel-Tail Grass. Common.

EQUISETACEAE. HORSETAIL FAMILY.

Genus *Equisetum*, L. Horsetail.

Equisetum pratense, Ehrh. Very common. The Indians eat the tubers of this plant.

A TRIP AMONG THE BIRD ISLANDS OF THE PACIFIC COAST OF WASHINGTON

PROF. ALBERT B. REAGAN, KAYENTA, ARIZONA

One bright morning we left Neah Bay, Washington, for a trip among the Roosevelt island bird reserves skirting the Olympic peninsula. We made for the lighthouse at Tatoosh island as we had mail for the government people there. As we neared it, the sea rose and fell and, with considerable effort, we lowered a boat which finally made shore amid the squawking of birds and the glad welcome of the life saving people. After a few minutes stay in the vicinity of this island, we sailed out over the halibut banks where the Indian creator Kwatte is alleged to have killed the destroyer Subbus. As we were sailing over the placid waters watching the Indians haul up their fish, our Indian guide said:

"We are on sacred waters. This was the home of the great evil one, Subbus, a monster shark-like animal of the sea. Being advised about this beast's destroying all the fish of the ocean and even swallowing down whole canoe loads of men, canoe and all, Kwatte decided to kill him. So he came to the shores of this peninsula and built a dugout canoe of large size. This he filled with water. Into it he then threw heated rocks till the water was boiling hot. Then he would dip his body into the heated water as long as he could stand it. Again and again he repeated this performance. He was practicing in preparing himself to stand great heat; for Subbus, who was very hot inside, was to swallow him.

"When he had everything ready and had sufficiently proved himself against heat, he shoved his canoe out into the water. He then put his paddles into it. He also swung his sack of clamshell knives at his side where he could readily get the knives when needed. Then he got into the canoe and paddled out over the 'banks.'"

"You know," continued the guide, "Subbus lay on the bottom of the sea and drew the water down through his mouth with such force while sieving it to get something to eat that a great whirlpool formed from the surface of the

sea down to his mouth, a maelstrom of monstrous proportions. Kwatte knew where the feeding ground was and steered his canoe directly for it. As he proceeded, he sang:

" 'Here I am, Subbus. Here I come. Here I am. Come, swallow me. Here I come to your mouth. Swallow me.'

"As he neared the swirling waters, his canoe began to swerve first to one side and then to the other; but he kept paddling first on one side and then on the other with well balanced strokes to steady it and keep it in its onward, forward movement. At the same time he talked to it telling it to keep steady, not to turn over, but to keep straight ahead with even keel. To the very edge of the great funnel it went. Its prow went forward and projected over the great hollow space above Subbus' mouth. For a moment it remained suspended in mid air. Then it went down endwise, straight down through Subbus' mouth into his stomach with Kwatte lying snugly in its bottom. He was inside, now, to to do his work.

"He used the big canoe as a ladder or steps to climb upon. On it he climbed to its top in the huge stomach. Then he began to cut with his clamshell knives, cutting at the inner linings and muscles. From side to side he moved his canoe and cut and cut and cut. The infuriated monster was felt to plunge and pitch in his agony, but he could not get rid of his enemy. At last he made one powerful, terrible lunge. Then he rose to the water's edge and floated on the surface dead. Kwatte had killed him. Since then it has been safe to fish in these waters."

By this time we were nearing Flattery rocks off the Indian village of Ozette. As we approached these islands, the suspecting birds gathered over us and soared about, screeching to try to scare us away, being fearful lest we would destroy their young. We proceeded. As we did so the Indian guide assured us that the birds' screeching was the cryings and wailings of the beings that the rocks had once destroyed. He further assured us that the birds were the returned spirits and that each rock was once a mon-

strous living being in whose powerful and gigantic mouth even whole canoe loads of people were swallowed down, canoe and all, at a gulp.

We neared the island we sought to ascend first, tacking our canoe as we came close to it. The canoemen then shoved the craft up to the foot-rock, which shelved somewhat out to sea from the almost perpendicular wall of the island which extended heavenward over one hundred feet. Then by a "swinging" of the boat backward and forward in a side movement with the waves, we jumped from it onto the foot-rock and briskly scampered up the island before the next wave struck us.

Soon we were on top of the island. And such a horrible noise as the birds did make; and who could blame them? From time immemorial their home had been sacked by cruel man. But we were not there for that purpose. The poor birds, however, did not know this. The shrieking of the mothers scared the young and they even jumped off the rocks and perished. We looked over the island and made an estimate of the birds. We also dug up a few of the burrowing fowls to be sure that they were denizens of the place. But the birds did not take to our intruding on their domain. An angry mother petrel spat on us and a sea parrot ruined my coat with her powerful beak while I was trying to photograph her.

Leaving this rock we went over to the Indian village and were lucky to encounter a medicine performance of the old type. An old medicine man was dipping his hands in water and doing a crude massage on the sick one. It seemed to be a case of heart trouble. Finally the medicine man took his pocket knife and cut out the skin in a circular ring about as large as a saucer over the heart region. Then he began to suck on the afflicted parts with his protruded lips as the blood besmeared his face. Suddenly he jumped to his feet as he gripped his hands tightly together and exclaimed: "I've got the 'Skukum.' I've got the sick." He then showed us some hard, black substance of considerable size between his fists. It was something black; but what? This the doctor burned in the room fireplace and the patient was well at once.

After a half hour's stay at this village, we left for another group of islands to the southward. At about four o'clock we came to Carrol Islet; and as it had trees on its top we ascended it. Reaching its top, we prepared to stay there for the night. Also one of the Indians took the canoe ashore and dug up some clams; and we had a clam bake for supper.

That night we slept in the open air and thought we had the place all to ourselves. But not. The night birds found us, the owls, hawks, petrels and parrots. We were strangers. We were trespassing and they were not slow to tell us so. The petrels got so close to us that I caught one of them with my hands. We slept but little till the night birds retired at the coming of the dawn. It was eight o'clock before we awoke.

To sharpen our appetites after we arose, we went to the northeasternmost part of the island. There we examined some birds' nests and took a few pictures. Then we descended down a ledge as far as we could safely go on the footing at hand. But our desires were not satisfied. Far below us was a ledge in hogback shape extending as a bench out from the main body of the island. This was covered with sea birds and their young. Birds by the hundreds were there. We got a rope from our boat and slid down it to the bench. And such a "Niagara" of birds followed. They swooped off the narrow ridge in one continuous stream. We ventured not on the land projection farther than where we first landed, lest we might cause the young birds to commit suicide by dumping themselves over the cliff. But we got some excellent pictures, both of young birds and of the worried mothers. We then returned to the top of the island again.

It had been evident to me that the islands were the jotting remains of promontories and headlands of the coast adjacent and I called the attention of my colleagues to the fact, as we were breakfasting. To our surprise, our guide spoke up saying that that was easily explained. He continued:

"Our people have a myth which explains the origin of the islands, promontories and headlands as follows: It was long ago when people were animals and animals people.

Kwatte was then still living on earth. He had his house on the beach near here; but he did not get hardly anything to eat, for the wolves of the region prowled the coast, caught the salmon, ate all the berries, and devoured all the animals of the woods, and gulped down all the fish eggs that floated ashore. What was Kwatte to do? One day the chief of the wolves came along up the coast. He came to Kwatte's house. Kwatte pretended to be sick. The wolf came in. He made himself at home. Kwatte let him stay. That night he made his bed in Kwatte's house beside Kwatte's fire. Soon he was fast asleep. When he had been asleep for a considerable time he began to snore. He snored loud. This was Kwatte's opportunity. He would now 'get even' with the wolves; and he would also have some meat to eat. He got his knife; looked at it to see if it was good and sharp; then, finding it in good shape, he went to the mat on which wolf was sleeping and severed that animal's head at one blow. He then skinned the carcass and hung the skin up above the fireplace to dry. He then stored the meat safely under his bed and went to sleep.

"The next morning, bright and early, a wolf came tracking his chief up the beach. He tracked him to Kwatte's house. He entered the house. Said he to Kwatte, 'Did you see Chief Wolf?' Kwatte answered, 'No, I am sick. I have not been out of my house. I have not seen him.' 'But he came to your house. We tracked him here,' protested the wolf.

While Kwatte was talking, the wolf's slave, the blue jay, had gone over to Kwatte's fire to warm himself. As he was spreading his hands out before the fire, a drop of something fell on the upper surface of one of his hands. At once he perceived it was a kind of oil. He smelled it. At once he recognized it to have the same smell as the smell of his master. He said nothing but went out of the room. The oil had dropped from the skin that was drying. As soon as he was out in the yard, however, he told all the wolves what he had discovered; many wolves had not followed the tracks to Kwatte's house. The blue jay was crying, mourning the death of his master. The wolves all rushed into the house. Kwatte had anticipated trouble and had hung a basket of

combs near the door. As the wolves entered he made a quick move, seized the basket of combs, and before the wolves had time to lay hands on him, he sallied forth out of the door past them and into the woods nearby and then down the beach. The whole pack of wolves then followed him in hot pursuit. Time and again they nearly overtook him. But as they were just in the act of seizing him, he would take a comb out of the basket and drop it down on the beach in front of them, thus forming a point of land projecting from the mainland across the beach into the surging surf with some of the isolated teeth jotting up above the waves as islets. The wolves, of course, were compelled to climb over the promontories thus formed. Many of them they climbed over; but finally they gave up the chase. But Kwatte kept running till he had stood up all his combs on the beach."

After we had eaten our breakfast, we started to the Jagged Island group. Here we landed and climbed up the jagged rocks to the summit of the highest island. There we found many birds of the Cormorant family, also some Murrs. The mother cormorants flew away at our approach; but the murrs stood their ground and tried to protect their young till we even picked up one of them. But the young cormorants were a pitiable sight. With wings fluttering and mouths open, they panted, expecting their necks to be wrung.

As we were looking at the birds, our guide called our attention to the fact that a herd of sea lion were basking in the sun on the farther end of the island we were on. So we hastened to see them. We crawled over the rocks so as to make the least possible noise. I finally got within twelve feet of a large male. He was sitting on his lower extremities like the fabled mermaid, while he was moving his head from side to side as he bellowed continuously. Near him was a female scratching her head with one of her "flippers." Other males were roaring and shaking their shaggy heads; cubs were playing, and females were basking in the sun. Some one in our crowd "hallooed" and a stampede of lions followed. They rolled, tumbled, slid into the water and were swallowed up by the waves; and nothing was left us but the bare rocks and the frightened birds.

That afternoon we went on to LaPush and spent the night in the Indian village there. It was on a Sunday, and that evening we went to the Indian "Shaker" meeting, a Christian service of the crudest type. There in a tightly closed room we saw the shakers performing. Candles and a cross were to view. But the services! A big, fleshy woman was chanting, "Hi, hi, hi" and all—some seventy, were vigorously stamping the floor as they waved their hands in gyratory motion, shrugged and contorted their bodies, wried their faces and muscle-trembled in a self-hypnotic condition till the perspiration poured down their practically nude bodies and formed in pools on the floor. And by this performance these simple hearted people expect to gain entrance into heaven?

On the following day we visited Point Granville and the rocky islets adjacent. Among the latter is "Split" rock. To our surprise, our remarks about this particular rock brought forth another myth in explanation of its origin from our resourceful guide.

Said he: "In the long ago a brother of Subbus lived in Quinaielt lake, and once when Kwatte and his brother Kofish were journeying over the earth, the latter ventured out on the lake and was swallowed by Subbus. Discovering what had happened, Kwatte heated all the rocks in the vicinity and, constructing a huge pair of tongs, he hurled them into the lake till the water became boiling hot and Subbus floated on top of the water, dead. Kwatte then cut him open and secured Kofish, alive, but wished a moment later that he had left him to perish, as he had been changed into a hermit crab, the father of all the hermit crabs of our day. Disgusted at the sight of his deformed brother, Kwatte hurled the tongs into the deep, tong-end up. They are the split rocks you see. Kwatte then seated himself on that rock yonder facing the setting sun, and, drawing his mantle up over his head in hood-shape, he turned to stone. There overlooking the bay he sits with his face toward the land of the hereafter."

Completing our cruise, we returned to our respective homes, but the memory of what we saw will indelibly remain.

The scenery of the region is unsurpassed. Below timber line, except in some prairie districts, one sees and is engulfed in the stately timber. The immense size of the trees strikes awe to the newcomer. Furthermore, the hidden vales and unfrequented hillsides beckon the nature lover to partake of the unmistakable "call to the wild" and its sylvan beauty. To take an ocean trip as we did and visit the hundreds of points and islets that jot above the pounding, surging surf, one sees the broken effort of the land to stay the onward march of the destroying tide. On the islands he sees the homes of thousands of birds, mostly sea species, and hears their warning-fear calls, as his craft moves about here and there. He also sees the sea lion glide off the rocks into the water on his approach. He leaves his boat and climbs about on the stepping stones of the continent. From them he looks out over the deep, blue waters which occasionally take on a tinge of emerald and sometimes a glow of amethyst. He mounts Carrol Islet (275 feet in elevation) in his journeying, as we did, and is greeted by a "Niagara" of murrs fleeing from him in their fright. He mounts the highest point on the island and takes in the world about him. To the southward he can discern the dim outlines of Destruction Island with its precipitous coast and "reefs of destruction"; also the low sandy beach and the rugged rocks of the southward curving coast line which extends as far as the eye can see. Added to this view is the almost impenetrable evergreen forest which covers the entire coast; while here and there can be seen curling upward from some settler's cabin a column of black smoke. To the east in the immediate vicinity-foreground there rises precipitously out of the waving waters the forest clad, benched coast; and farther on the serrated tops of the hills rise higher and higher until their mantle of green gives place to a coverlet of glistening, eternal snow, and the summits of the white-robed, snow-capped Olympic Mountains are lost among the fleecy clouds of the azure blue above. To the west the salmon, sea lion, seal, porpoise, and whale jump and play at the surface of the waving waters, and the ships of the world pass to and fro. On every side all objects are pictured in the most delicate tints which seem to magnify them rather than subdue them.

PRELIMINARY REPORT ON THE BOGS OF NORTHERN ILLINOIS

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It is a fact not generally known to the public at large and even to the botanists of the state that in Lake County there are several bogs, small in size but possessing the characteristic vegetation and conditions of similar formations usually found much farther north. While these bogs may have been mentioned in local statements, so far as known to the writer, no technical description of them has appeared in print. This report is based on a superficial survey with the expectation of a more detailed study of environmental conditions and a discussion of suggested problems later.

So far seven bogs have been located and it is probable that there are others, although the conditions necessary for the production of bogs may be found only in Lake County and not in other parts of the state. These seven bogs are all within the limits of the Valparaiso moraine which is characterized by a soil consisting of clay or gravel, frequently containing a large percentage of calcium carbonate, and having an uneven topography, originally with many knobs and kettle holes. Most of these depressions have been included in the drainage systems of the rivers of the region, but a section in western Lake and eastern McHenry Counties on the divide between the Fox and DesPlaines Rivers still contains a few poorly drained or undrained depressions, and it is in these that the bogs are found. It is probable that bogs were formerly very numerous, as indicated by the many patches of deep peat shown on the soil map of Lake County, although of course peat is formed by swamp vegetation as well as by bog plants. These bogs are interesting, first, as furnishing the only specimens of bog types of vegetation to be found in Illinois, and second, as an illustration of the method by which many of the patches of deep peat have been formed.

As these bogs are found in Lake County approximately from ten to twenty miles west of Lake Michigan, the general climatic conditions are similar to those of Chicago and vicinity, but on the whole probably more extreme, and of

course the average temperature is colder than that of the rest of the state. The vegetation in these bogs would be exposed to cold northwesterly winds on the approach of cold waves, as they are far enough away from the lake to lose any tempering effect from those waters. The vegetation of this region was originally the prevailing Oak Hickory forest of Illinois, so that the patches of tamarack trees found in the bogs make a very striking contrast to the trees inhabiting the rest of this region.

DESCRIPTION OF INDIVIDUAL BOGS.

1. Cedar Lake Bog.—Cedar Lake is located in Section 32, T. 46 N., R. 10 E. It is about three-quarters of a mile long and half a mile wide and is roughly oval or pear-shaped in outline, with its longest diameter extending north and south. The water is shallow over most of the lake, but according to local testimony a rather deep basin is found in the north central portion. The shores show evidences of earlier stages of high water, three or four feet above the present level, under which conditions the waters of the lake had an outlet through a channel which apparently passed just northeast of the present railroad station, as its banks can still be traced in a southeasterly direction to another small lake called Mud Lake. The vegetation on the ridges surrounding the lake was originally typical oak hickory forest with large numbers of red cedar trees on the more exposed shores. These forests have been almost entirely cleared away with only a very open patch of forest remaining on the upland northeast of the lake.

The bog lies in the form of a crescent in the north end of the lake. It is separated from the shore on the north by a stretch of shallow water one to two hundred yards across containing grass hummock formation. At either end of the crescent the swampy space is narrow and partakes more of the character of the typical moat of open water which usually surrounds a bog. With the rough apparatus available, there was found to be a depth of at least ten feet of water under the mat in the center of the bog. The bog consists of a quaking mat whose framework is made up of the roots of dwarf birch, blueberry, and cranberry with filling of sphagnum moss and also marsh marigold, buck bean, cot-

Fig. 1. Young tamaracks on immature bog on Cedar Lake.

Fig. 2. Very mature bog near Allandale Farm, showing dead and dying tamaracks.

Fig. 3. Bog near Volo from the south, showing swamp, oak-hickory remnant on knoll, and tamaracks.

Fig 4. Edge of tamarack forest in bog near Volo. Swamp sumach in foreground.

Fig 5. Northern portion of bog near Volo, showing mature moat, blueberry heath and tamaracks.

Fig 6. Mature bog near Wauconda, showing old shore line, swamp, shrub zone and tamaracks.

ton grass and other bog plants. There are frequent openings in the mat of from six inches to two feet in diameter which contain floating mosses of spirogyra.

At the west end of the bog near the Allandale farm is an elongated cluster of young tamaracks containing about fifty trees, none apparently more than fifteen years old. There are also one or two isolated trees of about the same size near the center of the bog. Fig. 1.

The bog is of local importance economically because of its annual crop of cranberries. These plants grow luxuriantly and produce many berries, but on account of the unstable character of the mat, many people are afraid of venturing on it. Within the last five years at least one horse and one cow have wandered out on the surface of the bog and have gone down in a soft spot and been drowned.

From the features described this is apparently a very young or immature bog, and it would be interesting to know whether or not it has increased in extent within the memory of man. Local testimony as to its history is somewhat uncertain but it seems probable that it has not increased much in size in the last fifty years. It is agreed, however, that the tamarack trees appeared rather suddenly about twelve to fifteen years ago.

2. The Allandale Bog.—About five hundred yards west of Cedar Lake and northwest of the Allandale farm is a kettle hole of low relief, the center of which contains the remains of a small bog. This was artificially drained about ten years ago, but was evidently very mature long before the draining. The bog lies about fifteen feet below the surrounding upland, is oval in shape and about two hundred yards in its longest diameter. The substratum on the soil at this depression is peaty but solid, though soft and water soaked in a wet season. The slopes surrounding the depression were originally covered with oak hickory forests and here also a few trees are left on the west side. The land between this depression and Cedar Lake was cleared a number of years ago. In the depression the vegetation is very mixed. There are still standing the dead trunks of several large tamarack trees eight to ten inches in diameter. Fig. 2.

Testimony is lacking as to whether or not these died before the artificial draining of the bog. Ilex verticillata and Pyrus arbutifolia are abundant, and a few clumps of sphagnum have been found on the floor. On the other hand the presence of several more mesophytic families including Osmunda regalis and Aspidium spinulosum, also Solanum dulcamara, and even Maianthemum and one or two small trees, including oak and mountain ash, indicate that the bog was mature and conditions had become quite mesophytic even before it was drained.

3. Volo Bog.—The depression in which this bog is situated is located near the center of Section 28, T. 45 N., R. 9 E., about one and three-quarters miles northwest of the town of Volo. This depression also is oval with its largest diameter north and south and with two connecting valleys or extensions, one to the southwest and the other curving around to the northwest and west. The depression is approximately three-quarters of a mile in length by one-half mile in width. It is surrounded by ridges of morainal gravel averaging about fifty feet above the floor of the valley, and like Cedar Lake the surrounding slopes show evidences of lake erosion at a previous stage of high water. The depression drains from the southwest corner into Sullivan Lake situated about a quarter of a mile distant.

The south end of the depression has a level floor of glacial clay, in one place rising into a hillock about one hundred yards in length by fifty in breadth covered by an open stand of oaks, mostly white and ellipsoid. Fig. 3. This clay floor is covered with water to a depth ranging from one to three feet at different seasons. The vegetation is pronounced tussock formation with scattered Betula pumila and occasional clumps of willow. This formation covers approximately one-third of the depression and gives way rather suddenly to a mature tamarack forest bordered by a shrub zone consisting of chokeberry and swamp sumach. The latter is especially prominent and forms the largest growth of this shrub which the writer has seen in this region. Fig. 4. The floor of the tamarack forest is still slightly quaking and the undergrowth is made up largely of sphagnum and cranberry with frequent pitcher plants and some blueberries.

Passing north through the forest, the pitcher plants, swamp sumach and cranberries gradually decrease and the blueberries increase.

The northern part of this bog originally held a tamarack forest, but the trees have been cut with the exception of a narrow fringe on the east and northeast and the whole northern third is now a blueberry heath of perhaps twenty or thirty acres. Fig. 5. The floor is composed of peat but is rather solid with occasional wet spots, and the dominant types are blueberries and chamaedaphne with occasional ledum and a shrub zone of chokeberry and occasional swamp sumach around the outside. A small pond is reported in the center of the bog but the writer did not have time to ascertain its shape, size or other characteristics. On the northwest side of the bog, the swamp formation from the south narrows down and changes decidedly in the character of its vegetation. A belt of shrubs and small trees is found next to the tamarack forest, and between this and the shore is a stretch of equal width covered with sedges and grasses. This extends to the northwest corner of the depression, but the tree zone seems to have been less extensive toward the north consisting mostly of willows and has recently been entirely cut away.

The original oak hickory forest of the upland has been almost entirely cut, but there are some patches remaining on the hills to the southwest and northwest as well as the clump previously mentioned on the morainal knoll in the swamp.

There was little opportunity to study the environmental factors of this bog, but tests of acidity of the substratum show it to be neutral for the tussock formation and for the old moat on the west, of moderate acidity for the floor of the tamarack forest and of the blueberry heath, and of a slight alkalinity for the morainal slopes.

4. Wauconda Bog.—This bog is situated in the southwest quarter of Section 25, T. 44 N., R. 9 E., on the southern outskirts of the town of Wauconda. The general shape and location of the bog is similar to that of Volo, with a grass

association on the south, a tamarack forest covering about half of the depression and the remains of a moat on the north. The substratum in general is drier than that of the Volo Bog.

The valley sides also show evidences of a previous stage of high water. Several years ago an attempt was made to drain this depression into Wauconda Lake to the north, but it was abandoned because there was not sufficient difference of level to enable the bog to drain into the lake. Fig. 6.

The floor of the depression is much drier than that of Volo and the vegetation is more advanced. There is no sign of quaking in the forest floor. The pitcher plants and sphagnum are very few and other more mesophytic plants have come in, including at least three young oaks.

Two other tamarack forests were observed to the northwest of Volo Bog, but they have not yet been visited. From reports they seem to be of the same nature as those of the Wauconda Bog. They will be visited as soon as possible and included in the final report.

This paper has attempted only to describe the location and general features of the bogs so far discussed and visited. There has been no attempt to discuss the problems presented as there has not been opportunity to observe the necessary data for such discussion. Work along these lines is now being carried on and will be reported later.

Two features at least may be noted, first, that these bogs apparently represent very different stages of maturity, ranging from the Cedar Lake bog which is very young, to the adjoining Allandale pocket which is the most mature of those observed. Secondly, the condition of Cedar Lake bog suggests very strongly the probability that it is of rather recent origin—perhaps much later than the end of the glacial period. If this can be proved, it will overthrow the present opinion that all of the northern cold bogs are direct relics of glacial invasion.

Fig. 1. Young plant with numerous juvenile shoots.

Fig. 2. Detail of plant showing branched juvenile shoot.

NOTE ON JUVENILE LEAVES IN THUJA OCCIDENTALIS

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The specimen described was obtained in the course of some experimentation on juvenile leaf production in Thuja occidentalis, suggested by some unpublished work by Doctor Land of the University of Chicago. Land reported that he was able to produce juvenile (needle) or adult (scale) leaves by varying the moisture condition of the air surrounding the young plants.

Among the specimens being studied were three plants each about three years old which had been placed in dry conditions. These in some way were overlooked, and when noticed again one was dead, the second nearly so, and on the third about half the branches had died. This third plant was revived simply by furnishing abundant water to the soil in its pot. The dead branches fell off, and new juvenile shoots appeared in many places on the main stem and branches. Fig. 1.

It is generally known that the seedling of Thuja consists simply of one elongated tuft of rather soft needle leaves. In the second year this elongates and usually one side branch appears and bears scale leaves. These scale leaf branches increase in numbers in succeeding years but for a number of years the end of the main axis bears the needle leaves, until it is finally lost sight of and presumably fails to continue growth after the tree increases in size. It has been noticed that young shoots coming out at the base of the main stem in conditions of strong shade and moisture will usually be of juvenile type.

In this case, juvenile shoots appeared in great numbers on all parts of the plant and one in particular, shown in Figure 2 has branched, but both branches bear juvenile leaves. In observing the specimens collected for this work, it was noted that there was considerable evidence of individual specificity in the production of juvenile shoots, individuals producing them rather freely, when apparently similar individuals under similar conditions produce only scale shoots. The specimen before its partial desiccation had

shown a notable tendency in this direction, one of its lower adult branches having four side branches tipped with juvenile shoots.

No definite conclusions can be drawn from this observation, but it is interesting to notice that extreme production of juvenile shoots followed resuscitation after at least partial killing of the young tree; that the conditions usually regarded as favoring the juvenile shoots were not employed in its resuscitation; and that this plant had always showed an unusual tendency toward the production of juvenile shoots.

A PRELIMINARY KEY TO SOME FOREST TREE ROOTS

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During the past several years the writer has had occasion to dig up and examine large numbers of tree roots. It has been necessary also to know what kind of roots were being examined in each case. This sometimes has involved hours of hard work, for in the woods where the roots of numerous trees are intermingled it is sometimes necessary to trace a root for a considerable distance through the soil in order to determine to which particular tree it belongs. It early became apparent, however, that there are characteristic differences by means of which some kinds of roots may be distinguished from certain other kinds. The recognition of this fact led to an attempt to learn the distinguishing characteristics of the roots of the genera that were most frequently dealt with, and finally to utilize these characteristics in the construction of a workable key.

It is obvious that a key based on the characters of a single member of the plant cannot be so completely satisfactory as one based on the characters of the plant as a whole. This would be true whether we were dealing with roots, stems or leaves. Yet either stems or leaves might be classified into groups on the basis of readily recognized characters and such classifications might prove very useful in case no other members of the plants were available. Likewise it is true of roots that while it would be impossible to identify many plants by the roots alone yet having learned root characteristics it is easy, for instance, to tell that oak roots are not maple roots.

The following key and descriptions are offered, then, not as a finished product nor in the hope that it will enable workers to recognize readily all of the roots considered at all times and under all conditions. They are offered rather as a beginning of an effort to differentiate the roots of woody plants and in the hope that since the scheme has proven of use to the writer it may also be of some service to others. It is entirely possible if not probable that in some instances I have failed to fix upon the most dependable

character and that further study will reveal other characters that may be used to greater advantage. It should be said too that the characters as used apply primarily to the superficial layers of soil to a depth of about one foot since the mycorrhizal characters would not apply, as a rule, to the deeper roots.

The characters of which most use is made are the presence or absence of mycorrhizal structures, the colors of the root bark and the relative size of the ultimate or smallest branches. The appearances of the various types of mycorrhizas has been described in a previous paper.[1] Although living ectotrophic mycorrhizas are usually absent from all trees in late spring and early summer, yet in case of trees which habitually produce mycorrhizas there is nearly always abundant evidence of them in the dead coral-clusters of mycorrhizal roots. The color of the bark that is taken is the color just within the surface after the dirt and the outermost surface layer have been scraped away by means of a blunt instrument such as the edge of a garden trowel. The size of the smallest branches of the root systems of various plants varies greatly in different species and is reasonably constant. The smallest roots of some trees are very coarse, those of others very fine and those of a third group are intermediate in this respect. An intermediate size of roots does not make a good key character but it has been possible in the following brief key to use this character only in those cases in which the roots are either conspicuously coarse or fine.

Other characters that are used in the key are the colors of ectotrophic mycorrhizas, the odor of the roots, the presence or absence of endotrophic mycorrhizal "beads" and the presence or absence of stiff brown root hairs. The first two of these characters are obvious without any explanation while the endotrophic mycorrhizal beads and the thick-walled root hairs have been described in earlier papers.[2]

1. McDougall, W. B.—On the Mycorrhizas of Forest Trees. Am. Jour. Bot. 1:51-74. 1914.

2. McDougall, W. B.—loc. cit. and Thick-walled root hairs of Gleditsia and related genera. Amer. Jour. Bot. 8:171-175. 1921.

KEY

A—Ectotrophic mycorrhizas abundant		B.
AA—Ectotrophic mycorrhizas infrequent or lacking		D.
B—Bark red	Carya ovata	1.
BB—Bark yellow	Carpinus caroliniana	2.
BB—Bark brown		C.
C—Mycorrhizas usually white—Quercus rubra and Q. muhlenbergii		3.
CC—Mycorrhizas usually brown—Tilia americana		4.
D—Ectotrophic mycorrhizas present		E.
DD—Ectotrophic mycorrhizas lacking		G.
E—Bark brown	Ulmus americana	5.
EE—Bark whitish	Carya cordiformis	6.
EEE—Bark yellowish		F.
F—Ultimate branches fine—Celtis occidentalis		7.
FF—Ultimate branches coarse—Aesculus glabra		8.
G—Endotrophic mycorrhizal beads present	Acer	9.
GG—Endotrophic mycorrhizal beads lacking		H.
H—Stiff brown root hairs present		I.
HH—Stiff brown root hairs lacking		K.
I—Ultimate branches fine—Cercis canadensis		10.
II—Ultimate branches coarse		J.
J—Root hairs numerous—Gleditsia triacanthos		11.
JJ—Root hairs not numerous—Gymnocladus dioica		12.
K—Roots with odor of walnuts—Juglans		13.
KK—Roots without odor of walnuts		L.
L—Ultimate branches fine—Morus alba		14.
LL—Ultimate branches coarse		M.
M—Bark black—Asimina triloba		15.
MM—Bark brown—Benzoin melissaefolium		16.
MMM—Bark whitish	Fraxinus	17.

1. *Carya ovata* (shag-bark hickory)—Ectotrophic mycorrhizas abundant, often yellow but sometimes white or brown. Ultimate branches moderately fine. Growing tips soon becoming brown. Bark distinctly red when scraped. The general appearance of these roots is similar to that of red oak and basswood but they are distinguished from the latter by the red color of the bark.

2. *Carpinus caroliniana* (blue beech) — Ectotrophic mycorrhizas abundant, usually white. Ultimate branches moderately fine. Growing tips soon brown. Bark yellow when scraped. Distinguished from oak, hickory and basswood by the color of the bark.

3. *Quercus rubra* (red oak) and *muhlenbergii* (yellow or chestnut oak)—Ectotrophic mycorrhizas abundant, more often white though sometimes brown. Ultimate branches moderately fine. Growing tips soon becoming brown. Bark distinctly brown when scraped.

4. *Tilia americana* (basswood)—The roots of the basswood very closely resemble those of the oaks. It is difficult in most cases to distinguish them. The difference noted in the key is that the mycorrhizas of basswood are more

often brown while those of the oaks are more often white but it must be admitted that this is not a constant or dependable difference.

5. *Ulmus americana* (American elm) — Ectotrophic mycorrhizas present but usually not abundant, usually light brown in color. Ultimate branches fine. Growing tips whitish but soon becoming brown. Bark brown when scraped.

6. *Carya cordiformis* (pignut hickory) — Ectotrophic mycorrhizas present but not abundant. Ultimate branches intermediate in size. Growing tips creamy white. Bark creamy white when scraped.

7. *Celtis occidentalis* (hackberry) — Ectotrophic mycorrhizas present but not abundant. Ultimate branches very fine. Growing tips whitish, usually rather short. Bark yellowish when scraped.

8. *Aesculus glabra* (buckeye)—Ectotrophic mycorrhizas present but not abundant. Ultimate branches very coarse. Growing tips soon becoming gray. The older bark is easily peeled off in flakes or layers, the outer layers being soft and punky. Bark yellowish, sometimes tinged with pink.

9. *Acer saccharum* (hard maple), *A. saccharinum* (silver maple) and *A. rubrum* (red maple)—Ectotrophic mycorrhizas lacking. Endotrophic mycorrhizal beads present, usually more abundant and conspicuous in the soft maples than in the hard maple. Ultimate branches intermediate in size. Growing tips remaining whitish for some time. Bark brown when scraped.

10. *Cercis canadensis* (red bud)—Mycorrhizas lacking. Ultimate branches fine. Growing tips whitish. Thick-walled root hairs present but not abundant. Bark light tan when scraped.

11. *Gleditsia triacanthos* (honey locust) — Mycorrhizas lacking. Ultimate branches coarse. Growing tips soon becoming brown. Thick-walled root hairs very abundant. Bark light brown when scraped.

12. *Gymnocladus dioica* (coffee tree) — Mycorrhizas lacking. Ultimate branches coarse. Growing tips whitish but soon becoming brown. Thick-walled root hairs present but not abundant. Bark dark tan when scraped.

13. *Juglans nigra* (walnut) and *J. cinerea* (butternut) —Mycorrhizas ordinarily lacking. Ultimate branches intermediate in size. Growing tips rather dark gray. Roots when broken or crushed having a distinct odor of walnuts. Bark yellow when scraped.

14. *Morus alba* (white mulberry)—Mycorrhizas lacking. Ultimate branches fine. Growing tips yellowish. Bark yellow to orange when scraped.

15. *Asimina triloba* (pawpaw) — Mycorrhizas lacking. Ultimate branches very coarse. Growing tips dark brown. Bark black when scraped.

16. *Benzoin melissaefolium* (spice bush)—Mycorrhizas lacking. Ultimate branches coarse. Growing tips light brown. Bark dark brown when scraped.

The spice bush never becomes a tree but it is included here because it occurs very abundantly along with the trees considered.

17. *Fraxinus americana* (white ash) and *F. quadrangulata* (blue ash)—Mycorrhizas lacking. Ultimate branches coarse. Growing tips dull white. Bark creamy white when scraped.

FOREST CONDITIONS IN ALEXANDER COUNTY, ILLINOIS

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INTRODUCTION

Among the reasons for selecting a portion of Alexander County to exemplify the forest conditions of southern Illinois accessibility is the most important. The Mobile and Ohio railroad traverses the eastern side of the county and the Illinois Central and Missouri Pacific the western edge. The fact that the northern portion has been topographically surveyed and mapped in the Jonesboro quadrangle and that a soil survey of the area has been made, although the results have not been published, made a forest survey more practicable. A further reason for its study is that both the "Ozark upland," or hill country, and the alluvial flood plain are well represented. The area included in this preliminary survey is limited to that part of the county included in the Jonesboro quadrangle and extends six miles southward from Union County and 15 miles eastward of the Mississippi, and includes about 82 square miles. Two-thirds of this is upland and the remainder in the flood plains of the Mississippi and Cache rivers. These plains range in elevation from 332 to 344 feet, while the hills reach an elevation of 800 feet above mean sea level at two or three points.

GEOLOGY

The eastern and more elevated portion of the area under consideration is immediately underlaid by rocks of Devonian age. The most recent are those referred by Savage (1) to the Early Mississippian and named by him Springville Shales. These and the underlying Devonian shales are known locally as "Calico Rocks" and are thus designated by Worthen (2) in an early account of the geology of the county. They are mostly gray to greenish rocks which on weathering become variegated and mottled in various shades of brown and red. In places in the vicinity of Elco these shales have become strongly silicified and are worked as

gannister and used in the manufacture of fire-brick. Such mines are to be seen near Cauble School, Sect. 1, T. 14 S., R. 2 W., and near Elco.

Below these shales are the sandstones and limestones of the Middle Devonian. The most conspicuous of these is the Clear Creek chert referred by Savage to the Ulsterian or Middle Devonian series. This has a total thickness of 300 feet and consists in large part of layers of more or less decomposed chert or in places in the upper portion of alternating layers of chert and limestone. From this formation most of the silicon in Union and Alexander Counties is obtained, while portions by decomposition form a white plastic clay or "kaolin." A silicon mine is now being operated at Delta. A quarry near Tamms exposes a vertical cliff of 180 feet which is largely composed of chert.

The Lower Devonian is represented by some limestones of the Helderbergian series seen within our area only in the river cliff between McClure and Gale. They are in contact with other limestones of Silurian age called the Sexton Creek formation. This consists in the lower part of a hard gray limestone in layers 4 to 8 inches thick separated from one another by 2 to 4 inch bands of chert. On the top is a bed of hard, fine-grained pink or mottled limestone in rather thick layers. It is well shown in the east bluff of the river, one and a half miles east of McClure and also along the valley of Sexton Creek. It varies in thickness from 16 to 79 feet.

In the northern part of the county there seem to be no rock exposures of formations older than the Sexton Creek limestones, but near Thebes are outcrops of Girardeau limestone. This Savage (3) places lower in the Silurian and refers it and the overlying Silurian limestones to the Alexandrian series because of their exposure in Alexander County. It is a dark, fine-grained, hard, brittle rock and has a total thickness of about 35 feet.

The oldest rocks in the county belong to the Ordovician and are the Thebes sandstone and the Kimmswick limestone. The former, a reddish brown arenaceous rock some 75 feet in thickness, is favorably exposed just south of the village

of Gale along a railway cut. The latter, occurring below the sandstone, is seen along a railway cut about a mile south of Thebes where it has a maximum thickness of more than 82 feet. It is mostly a light colored, coarsely crystalline limestone, its layers varying in thickness from a few inches to 4 or more feet. It is often called "Cape Girardeau Marble."

TOPOGRAPHY

The main lines of drainage are those of Sandy Creek and other small tributaries of Cache River along the east and southeast, Sexton Creek at the southwest and small branches of Clear Creek at the northwest. So complete is the dissection (Fig. 1) that none of the uplands show flat areas more than ¼ miles across and only the largest stream has a flood plain or terrace of greater width. In striking contrast the Mississippi flood plain is so nearly level that drainage is very imperfect.

SOILS

According to the classification adopted by the State Soil Survey the soils of the hill region belong to the upland timber types. The chief material of these soils is a fine wind-blown loess of considerable depth somewhat mingled, particularly upon the steeper slopes, with residual soil formed by the disintegration of rocks in place. This soil is very fine in texture, only moderately fertile, and with slight variations it covers most of the upland area. From its color it has been termed red-brown sandy silt loam. Along the streams, constituting the floor of the "Hollows," it passes to a light brown sandy silt loam. These silt loam soils are readily eroded both by surface washing and by gullying.

The soils of the flood plains of the rivers are mostly rather heavy clay loams varying from gray to drab and black. They have a high water-holding capacity and when properly drained are valuable agricultural lands.

FOREST TYPES

In a report on the forests of Illinois, Hall (4) has recognized for the southern portion of the state two classes of forest types, those of the upland and those of the bottomland. This classification may in general be followed while at the same time it must be recognized that the various

types and their subdivisions merge into one another by gradations that are often almost imperceptible, presenting degrees of difference that are quite impossible to discuss or map in a preliminary survey like the present study. In general two principal upland types may be distinguished, differing very considerably in response to water supply and expressing this response in varying degrees of density and richness as well as in the tree species present. Distinguishing these types by their principal trees, they may be designated as the upland oak and the beech-maple forests. The bottomland forests may be divided into three types termed respectively the streamside, the flood plain or "bottom" and the cypress swamp forests.

UPLAND OAK FOREST

This is developed upon the hill tops and along the more exposed slopes, particularly where the soil is poor and thin. It is dominated by various species of oak, the black oak, *Quercus velutina*, being most abundant especially upon the more exposed situations, while the white oak, *Q. alba*, abounds in more favored situations. There are smaller amounts of the chinquapin oak, *Q. Muhlenbergii*, of red oak, *Q. rubra*, and of two or three less abundant oaks. Other less important trees are the sassafras, the shagbark hickory, and the persimmon (Fig. 2).

BEECH-MAPLE FOREST

Upon the sheltered slopes and in the narrower valleys, particularly where the soil conditions are less severe, the oak forest passes into one dominated by beech, *Fagus grandifolia*, and the sugar maple, *Acer saccharum*. In the transition the first noticeable change is the disappearance of the black oak, the increasing number of red oaks and the invasion of the sugar maple. In addition to the species mentioned, there is also found the tulip tree, *Liriodendron tulipifera*, the black cherry, *Prunus serotina*, the red oak, *Q. rubra*, and about two species each of hickory and ash, while among trees of second size the Judas tree, *Cercis canadensis*, the pawpaw, *Asimina triloba*, and the hop hornbeam, *Ostrya virginiana*, are most abundant. On account of the extreme dissection of the upland it has been found to be impossible to indicate upon the map the distinction

between the two types of forest. In general the oaks are confined to the tops of the ridges and the gentler slopes, while in the ravines and at the bottom of the slopes the beeches and maples are found, hence both types are included under "upland forests" (See Map).

BOTTOM OR HOLLOW FORESTS

These are developed along the major lines of drainage of the upland region in the wider creek valleys often called "hollows" e. g. "Dongola Hollow" and "Happy Hollow." As these stream terraces and flood plains afford the largest tillable areas in the hill country, they have been almost completely cleared and hence only small fragments of this type remain. It was typically composed of such species as black walnut, *Juglans nigra*, the elms, *Ulmus americana* and *U. fulva*, the sycamore, *Platanus occidentalis*, the gums, *Nyssa sylvatica*, *Liquidambar styraciflua*, and the white ash, *Fraxinus americana*.

STREAM SIDE FOREST

This begins with the black willow, *Salix nigra*, developing at the water's edge and passes gradually into the bottom forest. The species that may be regarded as characteristic are the willow, the cottonwood, and the river or silver maple *Acer saccharinum*. In the narrow valleys occupied by the creeks very little stream-side forest is seen on account of the steep gradient, but it fringes the Mississippi and the smaller streams crossing its flood plain, and is found on many of the islands.

CYPRESS SWAMP FORESTS

The development of this forest is limited to depressions in the lowlands constituting the flood plain of the Mississippi River. As indicated by its name, it is characterized by the presence of the bald cypress, *Taxodium distichum*. Associated with the cypress is the tupleo, *Nyssa aquatica*, and with the filling or draining of the swamp the soft maple, *Acer rubrum*, the ash, *Fraxinus americana*, the pin oak, *Quercus palsutris*, and other species from the bottom forest appear.

GENERAL FOREST CONDITIONS

Practically none of the forest is in primitive condition, except small isolated areas on very steep slopes. On the

other hand much that has been mapped as forest has been so completely cut over that no merchantable timber remains, nor are the trees suitable for fuel sufficiently numerous to pay for the labor of cutting and hauling. The major portion of the wooded area is, however, in various stages culled forest (Figs. 3 and 4). The remaining stand often consists principally of small white and black oak with beech, maple and other less important species along the ravines. Where cutting has been done and grazing is not too heavy such pioneer forms as the sumachs, sassafras and persimmon are reestablishing a forest of inferior composition.

The general history of timber cutting has been, according to the testimony of those connected with the lumber trade for the past 30 or 40 years, that the tulip was cut first and that its cutting was most active during a decade extending from 1880 to 1890. This was quickly followed by a period during which the more valuable oak was cut, particularly the white oak. As soon as the larger oak was cut the smaller was utilized for railroad ties, and this cutting for ties has continued to the present, receiving a fresh impetus during the past few years during which beech has also been accepted for tie timber. Throughout this period there has been the usual cutting for posts and for fuel in addition to that for lumber.

The topography and the forests have exercised a marked influence upon the character of the population. The settlers are almost exclusively whites of mixed American stock. Upon the larger valleys along the line of the railroads the farms are moderate in size and the housing and living conditions show the moderate thrift of the small farmer (Fig. 5). On the contrary along the smaller streams like the branches of Sandy Creek, Dongola Hollow, Happy Hollow, etc., the farms are very small and relatively unproductive, while the houses and living conditions are decidedly primitive (Figs. 6 and 7).

Considerable portions of the wooded uplands are in holdings of 200 to 800 acres. These are usually but lightly grazed, the principal object of the owners being to hold

their land for the timber. This has made "squatting" a common practice in the past and one that has not entirely disappeared. Many deserted squatters' cabins are to be found in various stages of decay, while a few new ones have been erected during the past half decade and are now occupied.

The areas that have been entirely stripped of forest are the broader flood plains such as those of the Mississippi and Cache Rivers, the floors of the "hollows" and creek valleys and the tops of the hills. These have not only furnished the most accessible timber but have offered the only available land for agricultural purposes. The Mississippi flood plain has been very completely cleared, with the exception of some islands, such as Devil's Island, that are rather inaccessible and about which levees, such as those protecting the mainland, have not been built. Such islands are largely covered with low flood plain forests. There are also some imperfectly drained areas, such as those of Sections 14, 15 and 22 in Clear Creek Township, that are still covered with a culled cypress forest. The cleared and drained flood plain makes valuable farming lands.

The level portions of the "Hollows" or creek valleys are too narrow for anything except decidedly small farms and the soil is generally poor in quality.

The cleared hilltops have decidedly small areas of level soil, the water supply is deficient, they are isolated, and although the soil is fairly good they cannot afford more than decidedly poor opportunities for general farming. The most notable clearings of this sort are those of Dago and Vick Hills in Sections 4 and 10 of Delta township (see map), and portions of Sections 30, 31, 32 and 36 of the same township. Considerable portions of these areas consist of abandoned fields that on account of gullying have proved unsuitable for tillage.

The approximately 80 square miles included in this report consists of 2 square miles of the Cache River flood plain, 28 square miles of Mississippi flood plain and 50 square miles of uplands. Of the latter less than one-third has had any attempt at cultivation, and an area of at least 35 square

miles is unfit for any sort of agriculture. This is mostly in forest and "brush" and its economic utilization presents a series of most troublesome problems. Most of the forest has been culled and very little virgin woodland remains. Many of the cutover hill sides are in forest that shows little tendency towards the production of a valuable stand because it is being grazed and bush fires run through it so often that the most valuable species are killed and it is becoming changed into a black-oak hickory type, since sprouts of these species are more resistant and light conditions favor their introduction. Areas with better standing timber also show the effects of fire and grazing so that little or no reproduction is found (Figure 2). It would be no exaggeration to say that one half of this 80 square miles is quite unsuited for anything except the growth of forests and yet scarcely a square mile is in good productive condition, while no attempt is being made to improve its productivity. Further it is evident that similar conditions prevail throughout the most of the hill region of southern Illinois.

Wood Using Industries

A. VENEER INDUSTRY

The region under discussion lies between two consuming centers for veneer logs, one at Anna, Jonesboro, Cobden and Alto Pass using about a million and a half board feet every year and one farther south, at Karnak and Cairo, Illinois. At Karnak we have a very large plant operated by Main Brothers who specialize in material for egg and other crates while at Cairo more "hardwood" logs are worked up into veneers for sewing machines and furniture.

The term "veneer" covers wood in thin strips or slices used for berry boxes, hampers, tomato and egg crates, for a cheap form of "package." Hardwood logs, such as oak, can be put into sawed veneers which are glued over another cheaper wood, as in veneered furniture; or so-called "soft-wood" logs, such as elm, sycamore, red and black gum, maple, beech and tulip, can be veneered by the rotary process for packages which are very essential in the fruit, berry and vegetable trades. There is a good market for both varieties of logs in this region and the bottomlands are

pretty well combed for "softwoods" for these purposes, such logs being either hauled to the mills or loaded on cars at the railroad.

In making sliced or rotary cut veneers from logs they must first be steamed for from 12 to 24 hours, depending upon the species, after being cut up into bolts from two feet to six feet in length. After steaming, the bolt or short log, is spanned in a sort of lathe and turned past a large stationary knife which may take off a continual roll like a sheet of paper or short pieces like these on the sides of hampers. There may be considerable waste in this process, due to twisted grain, splits, frost cracks, seams, knots and other defects in the logs, but with perfect clear logs the number of square feet of veneer which comes off is considerable. Waste material, except the cores, which are used for pulp wood by some mills, may be used to fire the boilers. To understand all of the processes involved it may be necessary to take up the description of the making of different classes of veneered packages.

(a) Bushel Baskets to Contain Fruit

At present the main wood used for this purpose is black gum as it makes a nice white basket. For the top hoop of the basket oak was formerly used but now good ones are made from black gum, soaked before being bent.

To make these hoops, which give strength to the top of the basket and over which the cover fits, logs are sent into the mill in lengths of five feet, two inches. They are split into boards ⅞ of an inch thick with a band saw, with a kerf of 1/16 of an inch so that there is very little waste. These boards, after slabbing, are run through a machine with a series of small circular saws, like a lathe machine, which splits the boards into strips of the suitable thickness for bending. The main part of the basket, called the "web," is made by hand by laying strips on a circular form and joining them at the center. These "webs" are then sent to an automatic machine which turns out about five baskets per minute. Wire handles are also put on automatically from wire in rolls and the basket is ready for the cover. Baskets are dried outside on an open porch and the loss in drying is very small.

(b) Hampers

In the case of hampers which are used for shipping vegetables such as sweet potatoes, the staves are veneered, each one being 24 inches long. The bottom is made out of two half circular boards joined together with a staple, these bottoms being made out of the "cores" left by the circular veneer machine. It will be understood that when the logs are clamped in the machine and revolved for the taking off of the hamper staves, that a core is left in the center which may be six inches in diameter. These are split with saws and this is the material used for the bottoms of hampers and berry boxes.

Hampers are made on automatic machines, the staves being fed into the machine with the two narrow flexible strips which after being stapled will hold it all together. Good operators when speeding up with these automatic stapling machines can turn out 150 hampers per hour. Another form of package turned out by the mills and in large demand for shipping peaches and tomatoes is the popular four basket crate, the baskets nesting in a sort of box made from veneered strips, while some turn out small baskets used for shipping cantaloupes and cucumbers.

(c) Egg Crates

Main Brothers, Karnak, Illinois, specialize in the manufacture of egg crates or cases, the woods used for that purpose being mostly black gum and cottonwood. Most of the veneer mills find it profitable to have a saw mill in connection so that they can put some logs into lumber, and Main Brothers are large producers of cypress lumber. (Fig. 11.)

The Present Tendency in the Package Industry and Necessity of a Local Supply of "Softwoods" for Veneer Purposes.

Since Southern Illinois is a fruit and vegetable country, we believe it to be very essential for the prosperity of those industries that there should be a local supply of bottomland timber, such as elm, sycamore, cottonwood and gum, for the making of packages for shipping fruit and vegetables. This is a point which we believe those companies adding to their acreage of orchards are not appreciating as they should.

Some of the local veneer mills now see only a five years' supply ahead of them, which means that when supplies of this kind are shipped from more distant points that the shipper will have to pay more for them and this will have to be charged up to the consumer. It is the old story of "Jones, he pays the freight." There has been a big advance in the price of "knocked down" material for fruit and berry boxes, and barrels have reached such a price that their use for apples is almost prohibitive. This means that more fruit must be shipped in smaller veneered packages and that we will not buy in as large quantities as heretofore—again a greater hardship on the consumer.

Col. Greeley cites the fact that the supply of lumber for boxes is getting to be a very serious matter with the citrus growers in Florida. They use 12,000,000 boxes yearly, each requiring about 5½ board feet of lumber, while the shippers of garden truck require about 13,000,000 board feet additional. With the rapid exhaustion of Southern pine this may in a few years work great hardship to the citrus industry.

The same thing, we believe, is of importance in Southern Illinois and should lead men who do not need these wet bottomland tracts for farming to save them, since growth is rapid and there should always be a good market for the faster growing varieties of wood in the form of logs for veneer. There is also a chance to use such lands as game refuges without seriously interfering with their devotion to timber growing, a fact which will interest our sportsmen friends whose lakes and ponds have been taken over for agriculture. Some of these bottomland woods in the vicinity of McClure also contain a considerable per cent. of cypress which will always be a valuable species, worthy of encouragement wherever it occurs naturally.

B. SAWMILLS

The sawmills in this region may be divided into two main classes, (1) small portable mills which do contract sawing and (2) larger mills, owned by hardwood, coal or veneer companies.

(1) *Portable Mills.* Up the hollows in Alexander County, at quite a distance from the beaten track, you will

find piles of sawdust and mill refuse indicating the former sites of portable mills, the timber having been "sawed out" and the mill moved to some other place. Again, you will see smoke drifting up from one of these same hollows, or at the mouth of it, which proves to be from one of these portable outfits. Many of these mills have been engaged in sawing beech ties or beech car stock, but in many localities the supply of beech is getting pretty well exhausted. (Fig. 8.) The crew consists usually of four men, an engineer and fireman; a setter, since the mill is usually "hand set"; a sawyer, who is often the proprietor himself; and an "off bearer," who takes away the boards and edgings. The mill has usually cable or "rack and pinion feed" and a circular saw of from 48 to 54 inches in diameter. The output under the best conditions would be about 4000-5000 board feet per day. Sometimes these men purchase small tracts of timber at so much per thousand feet. Ties are sawed by the thousand feet and it takes about 31 or 32 railroad ties to make a thousand feet of lumber. The passing of the portable mill in such regions is a bad thing for the woodlot owner because it gave him a chance to have lumber sawed for farm buildings or for the market. The fact that there are so few portable outfits means that the timber is becoming exhausted and it is only occasionally that good tracts come into the market by the death of the older class of citizens who believed in saving their timber.

(2) *Larger Mills.* Some of these are found on the Jonesboro quadrangle at Mill Creek, Ware and Vineland and they usually have a more modern equipment and a permanent location along a railroad. Some of them are equipped with band saws and haul in logs with auto trucks from bottomland tracts which have been purchased. Sometimes they buy land and timber together and after cutting the timber sell the land for farming purposes. Usually they are located on a railroad and can fill special orders for ties or car stock and with considerable land to draw from can build up quite a little community in the small town where they are located, giving work to many laborers and teamsters. Very often veneer companies having a tract of con-

siderable size will operate a mill back in the woods, sawing up there into lumber any logs which are not large enough or clear enough to be hauled to town to the veneer plant. (Figs. 9 and 10.)

C. RAILROAD TIES

The production of sawed ties has been mentioned under sawmills, the majority of sawed ties being of beech which go to the creosoting plants for preservative treatment.

Hewed ties are made in the hills, mostly of black and white oak or in the bottomland timber after the larger trees have been removed down to a diameter of about twelve inches breast high, the tie men taking trees under this dimension. In the latter case we found almost any species being taken except cottonwood. The specifications for ties were as follows:

No. 1	6″ by 6″ face	8 feet long.
No. 2	6″ by 7″ face	8 feet long.
No. 3	6″ by 8″ face	8 feet long.
No. 4	7″ by 8″ face	8 feet long.
No. 5	7″ by 9″ face	8 feet long.

Prices received for ties varied from $1.00 to $1.90 delivered at the railroad, the latter price being paid for a No. 5 tie, without much distinction being made as to species, since most of them are now given a preservative treatment, even white oak. The price paid for hewing in the fall of 1919 varied from 30 cents each for a No. 1 tie up to 50 cents for a No. 5 tie. Two men usually worked together, maintaining a small temporary camp. There are quite a number of smaller trees of inferior species being cut for mine ties and motor ties, such species as mulberry, sassafras, ash, hickory, persimmon and mixed oaks being accepted, some being surfaced on only two sides, the price delivered being about 25 cents each. Hauling of ties is done on wagons, and for a six mile haul teamsters with a team were receiving about 20 cents each and could haul about 25 or 30 larger ties at a load. Taken all around, we may say that the hills of Alexander, as well as Union County, are capable under proper management and protection of producing large quantities of ties on land much better suited for timber growing than any other purpose.

Fig. 1 A portion of the Jonesboro Quadrangle showing the well dissected topography of the northern part of Alexander County with the roads and houses confined to the stream valleys and to the tops of the broader ridges.

Fig. 2. A rather open upland oak forest. White and black oak are dominant and reproduction is absent on account of grazing and ground fires.

Fig. 3. A cut-over upland forest. All the trees of marketable size have been removed. Some young growth is in evidence.

Fig. 4. An upland area that has been cut over and is now occupied by a low scrub.

Fig. 5. The border line between the flood plain and hill country in Alexander County. Note the cleared and cultivated plain and wooded hills.

Fig. 6. A typical squatter's house and farm quite shut in by forested hills.

Fig. 7. The home of the owner of a small farm in Ripple Hollow, Alexander County, Illinois.

Fig. 8. Type of portable saw-mill used in the region for sawing beech railway ties and lumber.

Fig. 9. Logs at a veneer mill in the yards ready to be cut into bolts for veneers.

A FORESTRY POLICY FOR THE FUTURE

In discussing a forestry policy for this region we might divide the forested lands into three classes: (1) the smaller woodlots; (2) large tracts held by coal companies, silicon companies, sand and gravel concerns, or coal companies; (3) those timber lands in the bottoms in organized drainage projects which are subject to overflow and may not come under cultivation for ten or twenty years.

1. Woodlots and Their Treatment.

Professor Frederick Dunlap, of the University of Missouri, at a recent Forestry Conference at the Union League Club in Chicago, mentioned a situation in the southern Ozarks of Missouri which seems to find its counterpart in Alexander County. He described the valleys of the hill country as being narrow so that the farmers in the winter made quite a large per cent. of their living from woods operations, carried on in the hill land. With the timber becoming scarcer the portable mills move out of the region, people who found employment in the woods leave and with scarcity of pupils the schools become depleted, with short terms. Those who do remain in the hill country find their main chance for winter employment gone with the rapid disappearance of the timber.

This shows a relationship between forestry and community welfare which does not exist in the Mississippi bottoms where the entire land is agricultural or destined to be cleared. Farmers having woodlots should not be too eager to encroach upon them for pasture or farming but should see that fires are kept out and that they are handled with an aim to future timber production, both for direct returns in money and indirect returns in preventing erosion, storing up water in the hills and making stream flow more regular. Farming of these patches in the woods must be attended with small profit after the superficial richness of the soil is exhausted and the fields are abandoned to erosion or allowed to go back to woods.

2. Policy to be Pursued by Owners of Large Tracts. Timber Land Acquisition by the State

In the hill country we find tracts of considerable size, up to 1000 acres, held by silicon and gannister companies, and

by sand and gravel companies. In walking through such tracts, signs of old and recent fires are seen, and it would seem to us to be good policy for these companies to protect their lands against fire even if the greater values do lie beneath the surface. Such companies might form cooperative fire protective associations to good advantage, increasing the value of these surface holdings by better handling of their tracts and at least by fire protection.

Where private companies do not take an interest in the protection of the timber on such tracts, it would seem to us to be good policy for the state to purchase the timber rights after a careful examination and forest survey, protect them from fire, carry on improvement cuttings and thinnings which might afford a small revenue at times and hold them as a future timber supply and protection forest. Some of these tracts from which the larger trees have been removed for lumber still have a potential value and in twenty-five years might produce a considerable amount of tie and saw timber. This has been mentioned several times by timber men in this part of the country so that I do not believe the acquisition of such tracts at a reasonable price to be at all a fanciful proposition and it would assure another cut of timber in twenty-five years; whereas if left in its present condition repeated fires will change the composition of the forest from white oak, tulip and beech to an inferior one of black oak and hickory with inferior growth capacity and hence low value.

3. Bottomland Which Might Grow Another Crop of Timber Before Being Needed for Farm Crops

There are occasional "forties" and sometimes tracts as large as 160 acres in drainage projects which contain fine timber, such as sycamore, elm, maple, hackberry, and white, pin and bur oak, that are subject to periodical overflow, making their value doubtful when cleared for agriculture. In one such virgin tract an elm was measured which was 30 inches in diameter at a height of 4½ feet above the ground, with a merchantable length of 42 feet and it scaled 921 board feet by the Doyle-Scribner log rule. One bur oak was measured which was 15.1 feet in circumference at a height of six feet above the ground, while a soft

maple scaled 1173 board feet. This will show to what size timber grows in some of these rich bottomland forests of which we have only an occasional example.

Very often in such tracts as this bayous are found containing stagnant water in the summer, which indicates that drainage after clearing may be unsuccessful and that such tracts, after taking out the larger timber, might be left for a second crop. The ordinary procedure is to take out the larger trees for logs, after which the makers of railroad and motor ties come in and clean up the remaining species, such as elm, soft maple, hackberry and sycamore while leaving a fair number of these smaller trees on the ground might insure a future crop. After the logging of cypress we have many acres where black gum comes in, and if the stand is sufficiently opened up to the light, the cottonwood and the willow. We have been informed by men who own large tracts of this land that it might not pay to raise cottonwood on a twenty year rotation on account of the high drainage tax which must be paid, in addition to ordinary taxes, although it might pay to grow willow, on a shorter rotation. Willow is used to some extent in Illinois for charcoal, for gunpowder, while cottonwood is now finding a sale for soda pulp. Charcoal can be made near the source of supply, but so far there are no soda pulp mills in Illinois to afford much of a market for cottonwood. It would seem that working for such industries to be established near St. Louis to use the cottonwood and other bottomland species suitable for charcoal and soda pulp so as to make a better demand for these species would be good forestry and just as essential as working for fire protection, better sylvicultural requirements or reforestation. Southern Illinois offers good opportunities for something of this kind due to rapid growth of the species mentioned, and the chance to utilize the smaller material from thinnings for mine timbers, mine and motor ties, and other similar purposes.

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VIVA

THIS CHART WILL BE THE FIRST CHART
APPEARING AT THE END OF THIS FILM

GROWTH AS RELATED TO SPECIFIC GRAVITY AND SIZE OF SEED*

MARY E. RENICH

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I. INTRODUCTION

The influence of the size and of the weight of seed on the resulting crop has been a subject of investigation for many years. The evidence gathered from the literature in this field seems to show that large, heavy seeds give the best returns. A considerable number of investigators find that their results are rather conflicting. Dehérain et Dupont (4) maintain that it is only when the difference in the weights of the seeds used is great, that there is a definite advantage in favor of the heavier seed. Meyer, C. H. (13) says that the question of advantage in the use of large and small seeds as associated with yields is inconclusive. Leighty, C. E. (11) condemns the method of selecting the largest seed without consideration of the character of the mother plant; and Love, H. H. (12) concludes from his results that the heavy grains of wheat and oats come from the tallest and heaviest yielding plants. Johannsen, W. (9) in his work on inheritance of weight shows that, in a population of beans, the heaviest daughter-beans

*This paper is the thesis, somewhat condensed by the omission of several tables, submitted by the author in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

are the progeny of the heaviest mother-beans, but that in a pure line this is not necessarily true. DeVries (5), on the other hand, thinks that the size and the weight of seed are primarily the result of nutrition, in the broad sense, rather than the result of inheritance.

In so far as specific gravity is concerned, another series of experiments has been carried on. Haberlandt, F. (6) found in working with wheat, oats, etc., that the denser grains yielded the heavier returns in grain, and that the less dense ones yielded the greater amount of straw. According to Wollny, E. (17) the absolute weight and not the specific gravity is the only true index of the value of the grain. Clark, V. A. (2) found that, except in the case of oil bearing seeds, the larger number of good seeds is near the upper limit of the specific gravity for the variety. He concludes, however, that specific gravity is of less importance than size in seed selection.

While each of these fields has been investigated by many workers, a few have considered the combined effect of size and of specific gravity in seed collection. Among the latter is Sanborn (16). He sorted wheat according to size and then separated the large grain into two groups by the use of a brine solution. The yield from his lighter grain surpassed that from his heavy grain. Degrully, L. (3) in working with corn, discarded all the very small and poorly formed grains. He then separated out the lightest one fourth by means of a sodium nitrate solution. He states that the difference of the results in favor of the heavy grain was remarkable.

Practically all experiments have been carried on under field conditions. They have had for their chief aim the influence of specific gravity and of size of seed on crop production. A few tests have been made by Kiesselbach and Helm (10) to find the relation of the "sprout value" to the yield of small grain crops. The term "sprout value" is defined by the authors as, "The moisture-free weight of the maximum plant growth derived from the seed when planted and grown in a non-nutritive quartz medium and in absolute darkness."

PLATE I.

AVERAGE SHOOT HEIGHT FOR SEEDLINGS GROWN IN WATER - 25°C

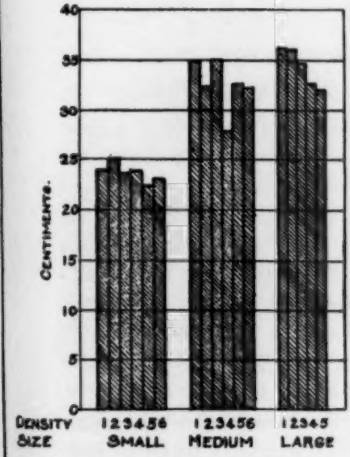


PLATE II

AVERAGE DRY PLANT WEIGHT FOR SEEDLINGS GROWN IN WATER - 25°C.

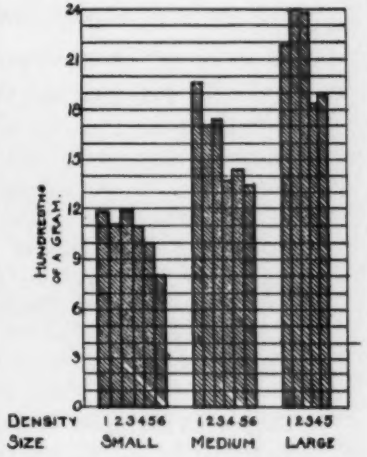


PLATE III.

AVERAGE SHOOT HEIGHT FOR SEEDLINGS GROWN IN SOIL - 25°C.

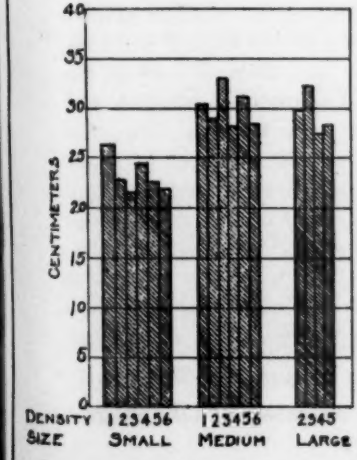
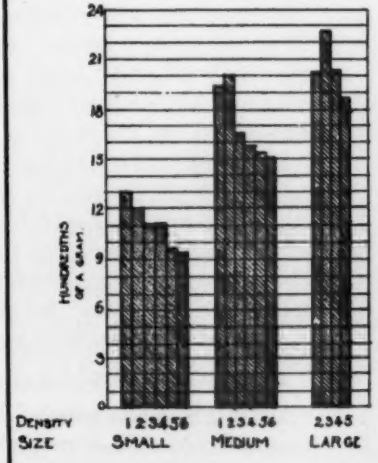


PLATE IV

AVERAGE DRY PLANT WEIGHT FOR SEEDINGS GROWN IN SOIL - 25°C



The problem of finding how much growth, due solely to the reserve food in the seed, will take place in seedlings from seeds separated according to specific gravity and to size has not, as yet, been studied. The solution of this problem is the object of the experiments here recorded.

II. MATERIALS AND METHDOS

(1) Selection and Separation of the Seed Used.

The common garden bean because of its ready adaptability to laboratory conditions was chosen for these experiments. In the spring of 1919, ten pounds of Burpee's Red Valentine seed of the season of 1918 were divided according to their specific gravity into six groups. This separation was made by means of solutions of chemically pure sodium nitrate dissolved in distilled water. A preliminary test showed that few seed sank in a solution of 1.32 specific gravity, or floated in one of 1.12. The solutions used consequently range from 1.32 to 1.12 specific gravity. They were prepared with the use of a Twaddell hydrometer, corrected for 60° F., and both seeds and solutions were kept at this temperature while testing. The solutions made up differed from each other in specific gravity by .05 and, in use, were not allowed to vary by more than .005.

A few seeds were placed in a small tea strainer, dipped into 95% alcohol to remove the air film and then transferred to a larger strainer immersed in a solution of sodium nitrate of 1.32 specific gravity. The seeds which floated were removed by a second small strainer and they as well as the ones which sank were rapidly and thoroughly washed, and spread out on towels in a warm room to dry. The ones which sank, after drying, were stored in glass jars for future use. After all the seeds had been passed through the solution of greatest density (1.32 sp. gr.), those which floated were taken in a similar manner through the solution next lower, solution of 1.27 sp. gr., etc. By this method six groups of seeds were obtained. These groups are designated in the discussion and in the tables as follows:

Density 1, seeds which sank in a solution of 1.32 sp. gr.;

Density 2, seeds which sank in a solution of 1.27 sp. gr.; (range from 1.32–through 1.27);

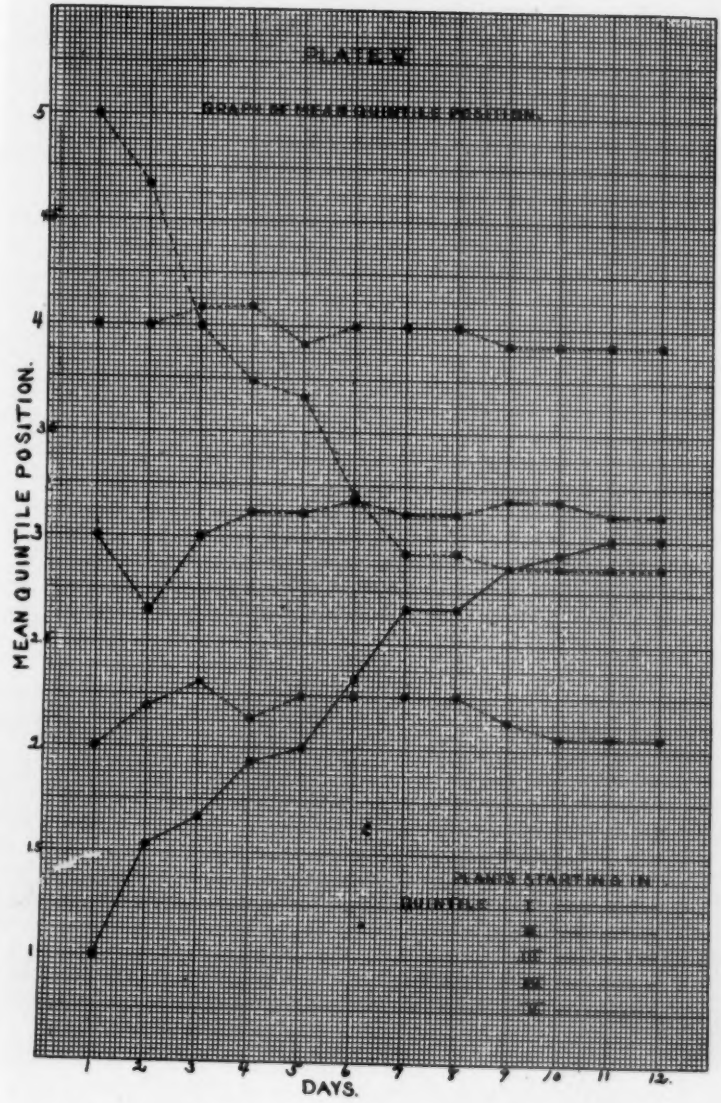


PLATE X.
GRAPH OF MEAN QUINTILE POSITION.
MEAN QUINTILE POSITION.
5
4
3
2
1
1
2
3
4
5
6
7
8
9
10
11
12.
DAYS.
PLANTS STARTING IN QUINTILE

Density 3, seeds which sank in a solution of 1.22 sp. gr.; (range from 1.27–through 1.22);

Density 4, seeds which sank in a solution of 1.17 sp. gr.; (range from 1.22–through 1.17);

Density 5, seeds which sank in a solution of 1.12 sp. gr.; (range from 1.17–through 1.12);

Density 6, seeds which floated in a solution of 1.12 sp. gr. By this method the seeds were exposed to the solution but a few seconds and, as germination and growth tests showed, suffered no harm from the process.

The seeds passed through the successive solutions varied in length from 8.3 mm. to 18.5 mm. These were divided into three groups of the following respective lengths:

Large seeds, range in millimeters from 18.5 to 15.1; medium seeds, range in millimeters from 15.1 to 11.7; small seeds, range in millimeters from 11.7 to 8.3.

(2) Treatment of Seedlings.

Twenty-four seeds of each group were individually weighed and measured. Twelve were placed in beakers of sphagnum, the others were planted, one quarter of an inch below the surface of the soil, in small flower pots. In putting the seeds to germinate, the micropyle end was always placed down thereby avoiding unnecessary curving of the seedling. The beakers and the pots were kept in covered metal cases at a temperature of 20°C during germination. When the seedlings in the sphagnum started to put forth secondary roots they were transferred to small aspirator bottles filled with tap water. This water is essentially a nutrient solution as the chemical analysis given by the Illinois State Water Survey (8) shows. The seedlings were held in place by means of fine aluminum wire and by a support which was fastened to the neck of the bottle. The bottles were then placed into the cases where they were left until the seedlings were ready for use. The water in the bottles was renewed on alternate days.

When the seedlings were one or two centimeters in height, the pots or bottles were placed into rectangular metal cases consisting of a lower part fifteen centimeters in

height and a tall upper part which fits down over the former leaving an air space of one centimeter between the lower and upper parts. By this means all light was excluded but air exchange was not prevented. These small cases were placed in special large constant temperature cases designed by Professor Charles F. Hottes. The seedlings were removed from the cases daily, measured and watered. During the period of measuring, approximately ten minutes, the seedlings were exposed to the light and to the temperature (20°C) of the laboratory. Seedlings deformed or otherwise abnormal were discarded. They were grown in series at temperatures 20°, 25° and 30°C. The large seeds, of which only a very limited number were on hand, were grown at 25°C only.

All measurements were taken beginning two and one-half centimeters above the root origin. If the entire height of the shoot is desired, two and one-half centimeters must be added to the total height of the shoot as recorded in the tables. In those cases in which the cotyledons were not opposite, the length of the hypocotyl was measured to the insertion of the lower cotyledon. The length of the internodes were taken from the lower part of one node to the lower part of the next higher or, in the case of the upper internode, to the growing point. A centimeter rule was used and the measurements were read to the nearest millimeter. From the record of these daily measurements, the daily growth increments given in the tables were obtained.

When a shoot showed no growth since the previous day its diameter, one centimeter below the insertion of the cotyledons, was taken by means of a vernier callipers. The seedling was then removed from the soil or the water, the root was washed, superficially dried, and separated from the shoot. Then the fresh weights of root and shoot were obtained. These parts were dried to constant weight in an electric oven. All weights were read to the fourth decimal place.

The data for the several series are given in *Tables 1 to 47. Data are given for individual seedlings grown at the temperature 25°C; for those grown at 20° and 30°C, the

data given consists of averages, taken in most cases from eight seedlings. In a few cases, where germination was poor, or seedlings were discarded because of abnormality or accident, the averages include a smaller number. Measurements of seedlings were taken to tenths of centimeters, but the calculation of averages was made to the third decimal place and are recorded to the second.

III. DISCUSSION

Daily observation of the seedlings made evident a striking correlation between the amount and rate of growth and the specific gravity and size of the seed. So marked and regular is the correlation that it was possible, as a rule, to select the seedlings from seeds of certain densities and sizes by their general appearance. This was especially true for the seedlings from seeds of Densities 2 and 3, for these appeared more uniform in size and consequently in the rate of growth. They were also more sturdy and of a deeper yellow color than those from seeds of the lower densities. Now and then a group from Density 4 would be mistaken for those of the higher densities. This is apparently in agreement with the results that Degrully (3) obtained in his work with wheat. He found that the plants from the denser grains were greener, more vigorous, and, during their early growth, showed a great superiority over those from the less dense grains. Because of heavy rains, his plants of both groups suffered greatly from rust and he was unable to make comparisons of the final growth. A study of the data as recorded in the tables shows that the differences noted in the seedlings are not differences of appearance only.

Because seedlings from seeds of all sizes and densities were grown at 25°C the *Tables 1 to 17 and 21 to 36 have the data given for individual seedlings. A comparison of individuals is not undertaken because that would lead to a study of individual variation. In order to show the superiority of some groups over others, the groups will be compared in respect to their average, maximum and minimum values. Because of differences between the seedlings grown in water and those grown in soil each culture will be studied separately.

1. Relation of Growth to Specific Gravity of Seeds at 25°C.

a. Water Culture.

Size.—A comparison of average values for the seedlings grown in water, at temperature 25°C can be most readily obtained by a study of Tables 18 to 20; for the maximum and minimum values, *Tables 1 to 17.

An examination of the average values for the heights of the shoots shows that the greatest and second greatest average heights of seedlings from seeds of each of the three size groups are for seedlings from seeds of Density 1, 2 or 3. These average heights are graphically shown in Plate I. In the hypocotyl and first internode no correlation between average length and specific gravity of seed is apparent, but a direct relation does exist between these factors in the second and third internodes, in that, the lower the density of the seed, the shorter the internodes. Fourth internodes developed only in seedlings from seeds of Densities 1 and 3. There is also a direct relation between average diameter of seedlings and specific gravity of the seeds; the seedlings from the denser seeds are larger in average diameter than those from the less dense.

In studying the maximum and minimum values of seedlings from seeds of the several densities, *Tables 1 to 17 are used. For the small seeds, the greatest shoot height is that of a seedling from a seed of Density 5. The second in height is from a seed of Density 3. For the medium seeds, the three tallest seedlings of the series are from seeds of Density 3. The two tallest seedlings from the large seeds are of seeds of Density 2, the third tallest, from a seed of Density 3.

As in the case of the average length of hypocotyls and first internodes so here, there exists no definite relation between maximum lengths of seedlings of the different groups and specific gravity of seed. In the second and third internodes, the maximum lengths for the several series are in every case, in seedlings from seeds of one of the three highest densities. There is a marked difference between the maximum lengths of these internodes in the seedlings

from seeds of the higher and lower densities. While in average values, the diameter of the shoot varied with the density, this does not hold true for the maximum values.

With but few exceptions the minimum values for shoot height and diameter are found in seedlings from seeds of Density 5 or 6, usually the latter.

From these comparisons we may conclude that, for seedlings grown in water at a temperature of 25°C.

(1) The greatest height and diameter of shoot are found in seedlings from seeds of Densities 1, 2 and 3; in Density 2 or 3 more often than in 1;

(2) The lower the density, the shorter the second and third internodes.

Weight.—That weight is related to density is clearly seen from a study of the tables. The average weight values are considered in Tables 18 to 20. In the case of the fresh weights of roots, shoots and plants for seedlings from the large and the small seeds, the three greatest average weights for each size group are found in the seedlings of the three highest densities. For the medium seeds, the highest average fresh root weight is in the seedlings from seeds of Density 4, but the second highest is in those of Density 1. The highest average values for fresh shoot and fresh plant weights for the seedlings from these medium seeds are in those of the three highest densities as was the case for the seedlings from the small and large seeds.

The maximum fresh root weight for the small seeds is found in a seedling from a seed of Density 3; for the medium seeds from a seed of Density 4; and for the large seeds, from a seed of Density 2. The maximum fresh shoot weight for the small seeds is that of a seedling from a seed of Density 1; for medium seeds, of Density 1; for large seeds, of Density 3. The maximum fresh plant weights for seedlings from the small and the medium seeds are for those from seeds of Density 1; for the large seeds, for one from a seed of Density 2. The minimum fresh weights are usually the weights for seedlings from seeds of Density 5 or 6.

A better idea of the actual amount of growth can be obtained from the dry weights than from the fresh weights.

For the seedlings from seeds of each size group, the three highest average dry weights for roots, for shoots and for plants, are in the seedlings from seeds of the three highest densities. These average weights, however, do not vary directly as the densities, for the highest value is sometimes in seedlings from seeds of Density 3, sometimes in those from seeds of Density 1 or 2. Plate II represents the average dry weights for the seedlings of each group.

The maximum dry root weights for seedlings from the small, the medium and the large seeds are in seedlings from seeds of Densities 3, 1 and 2 respectively. The maximum dry shoot weights, and also the maximum dry plant weights are for seedlings from seeds of Density 1, for those from the small and the medium seeds, and Density 2 for those from large seeds. The minimum dry weights are, as a rule, in seedlings from seeds of Densities 5 and 6.

From these facts we may conclude:

(1) That, with the exception of the roots from the medium seeds, the greatest fresh weights are in seedlings from seeds of the three highest densities.

(2) The greatest dry weights are also in seedlings from seeds of the three highest densities.

Comparison of Weights.—There is little correlation between the relation of dry to fresh weight and the specific gravity of the seeds. It is apparent, however, that in the seedlings from seeds of Density 3 the average percentage which the dry weights of root, shoot and plant is of the fresh weights of the corresponding members is as great, sometimes greater, than that of any other density.

The average percentage which the dry plant weight is of the seed weight is always higher for the seedlings of seeds of Density 6 than for those from seeds of Density 1; in most cases it is also higher than for those from seed of Density 3. This higher percentage shows that although in size and weight the seedlings from the seeds of Density 6 are inferior to those of other densities, the seedlings from seeds of Density 6 appear to make the best use of the reserve food in the seed.

Rate of Growth.—Not only is the amount of growth related to the specific gravity of the seed but there also exists a relation between the rate of growth and the specific gravity of seed. Considering the rate of growth as shown by the daily growth increments we find that, in general, seedlings from seeds of the higher densities have a greater growth rate than those from seeds of the lower densities. The greatest average daily increment for the small seeds, 5.8 cm, was made on the second day after being placed in the constant temperature case by the seedlings from seeds of Density 6. For the medium seeds, the greatest average daily increment, 7.63 cm, was made on the second day by seedlings from seed of Density 3; and for the large seeds, an average daily growth of 6.85 cm was made on the third day by seedlings from seeds of Density 1. The maximum daily growth increment of the seedlings from small seeds is 7 cm, made on the second day by a seedling from a seed of Density 3; the maximum for the medium seeds is 9.3 cm, made on the second day by a seedling also from a seed of Density 3. For the large seeds, the maximum increment 7.7 cm was made on the third day by a seedling from a seed of Density 2. The average rate of growth often decreases more rapidly in the seedlings from seeds of the lower densities and although the total height of the seedlings from these densities is less than that for those from the denser seeds, growth usually continues for as many days as in seedlings from the seeds of higher densities.

b. Soil Culture.

The data for seedlings grown in soil at temperature 25°C is given in Tables 21 to 40. Tables *21 to 36 contain the records of the individual seedlings while the average values are shown in Tables 38 to 40. Because of the limited number of large seeds of Densities 1 and 6 none were grown in soil.

Size.—Proceeding as in the discussion of the seedlings grown in water, we find the greatest average shoot heights for the small, the medium and the large seeds respectively, are for seedlings from seeds of Densities 1, 3 and 3. The highest shoot from the small seeds is that of a seedling

from seed of Density 4, the second highest, of Density 1; the two highest for the medium seeds are from seeds of Density 3; the highest for the large seeds is from Density 2 while the second highest is from Density 3. The minimum value for each size group is in a seedling from seed of the lowest density.

No correlation exists between density and average and maximum length of hypocotyl and first internode. The lengths of the second and third internodes vary as the density of the seeds. No seedlings grown in soil developed a fourth internode. As to the diameter, we find the average size varies as the density of the seed; the maximum values are also in the diameters of the seedlings from seeds of the higher densities.

In so far as size of seedlings is concerned, the results agree in general with those for water grown seedlings,—

(1) The greatest height and diameter of shoot is found in seedlings from the seeds of Densities 1, 2 and 3. More often in seedlings from Densities 2 or 3 than Density 1.

(2) The length of the second and third internodes vary as the density of the seed.

Weight.—There is more variation in the fresh weight of soil-grown seedlings than in those grown in water. This is especially true in the root weight. In the roots of seedlings from small seeds the greatest average and maximum weights are for those from the higher densities and the minimum weights are in those of lower densities, but no general relation seems to exist between fresh root weight and specific gravity for seedlings from the medium and large seeds.

In the fresh shoot weights we have the greatest average weights for the small, the medium and the large seeds in those from seeds of Densities 1, 2 and 3 respectively. The maximum fresh weight for each size group is in a seedling from a seed of Density 3 while the minimum weights are in those from Densities 5 or 6, usually 6. In the fresh plant weights we find the same order as in the shoot weights the greatest average weights for small, medium and large seeds are in seedlings from seeds of Densities 1, 2 and 3

respectively; while the maximum weight for each group is in a seedling from a seed of Density 3; the minimum weights are in those of Density 5 or 6, usually 6.

In the dry weights we find a definite relation between density and weight. This correlation with plant weight is graphically represented in Plate III. Without exception the highest average and maximum weights for each size group are in the seedlings from seeds of Densities 1, 2 or 3. This statement holds true for dry weights of root, shoot and plant. Moreover, the second highest average and maximum weights are in most cases also in seedlings from seeds of these higher densities. The lowest average and minimum weights are for seedlings from seeds of the lower densities.

Comparison of Weights.—The facts pointed out for seedlings grown in water with respect to correlation between dry and fresh weights and specific gravity of seed hold true for those grown in soil. The seedlings from seeds of Density 6 appear to lead in making the best use of their reserve food as was the case in the water culture.

Rate of Growth.—A study of the daily growth increments also points to a superiority of the seedlings from the denser seeds. In the case of average daily increments (Tables 37-39) we find the greatest average increment for the small seeds is 7.56 cm on the third day for seedlings from seed of Density 1; for medium seeds, 8.9 cm on the second day by those from seeds of Density 3; for large seeds, 7.67 cm on the second day by those from seeds of Density 1. From *Tables 21-36 we obtain as maximum daily increments, for small seeds, 8.5 cm on the third day by a seedling from a seed of Density 1; for medium seeds, 10 cm on the second day by two seedlings from the seeds of Density 5 and one from those of Density 3; for the large seeds, 10.1 cm on the second day by a seedling from seed of Density 1.

Summing up the results from the data for seedlings grown in water and in soil at 25°C we find the following relations exist between specific gravity and growth:

(1) The greatest height and diameter of shoot are found in the seedlings grown from seeds of the three highest densities;

(2) The higher the density of the seed, the longer the second and third internodes;

(3) As a rule, the seedlings from the denser seeds have the highest fresh weight;

(4) The greatest dry weight is always found in seedlings from seeds of the three highest densities;

(5) The seedlings from the higher densities show, on the whole, a greater rate of growth than do those from seeds of the lower densities.

2. Relation of Growth to Size of Seed, at 25°C.

Size.—That a definite relation exists between size of seed and amount and rate of growth is shown beyond a doubt by the results of these experiments. For both water and soil cultures the seedlings from small seeds are smaller than those from medium and large seeds in height and in diameter of shoot. This fact in regard to shoot height is clearly shown in Plates I and III. From these plates we see that the seedlings from small seeds are not only shorter than those from medium seeds of the same density but the seedlings from the small seeds of the highest density are shorter than those from the medium seeds of the lowest densities. Both the numerical data and these plates show that there is less difference in height between the seedlings from medium and large seeds than there is between those from medium and small seeds. The average heights for seedlings from the medium seeds from Densities 3 and 5 (Table 19) are greater than those from the large seeds (Table 20) of the same densities. The maximum heights for seedlings of Densities 1, 3 and 5 are also greater than the maximum heights for the large seeds of the same densities.

There is a greater difference between the diameters of the seedlings from small and medium seeds than between those from medium and large seeds. The lengths, both average and maximum, of the hypocotyls in seedlings from

the medium seeds are greater than those of the small or large seeds. There is little difference in the case of soil grown seedlings in the hypocotyl lengths of seedlings from small and large seeds. There is less difference between the length of the second and third internodes of seedlings from medium and large seeds than between those from medium and small of the same density.

Weight.—From the data given for fresh root weight (Tables 18 to 20) for water culture, we find that the average weight for seedlings from the small seeds of Density 3 is greater than that of those from the medium or large seeds of like density. The average weight for seedlings from small seeds of Density 2 is greater than that of those from the medium seeds of this density. Again, the average weight for seedlings from medium seeds of Densities 4 and 5 is greater than that of those from large seeds of these respective densities. The fresh weights for shoots and plants vary, for equal densities, as the size of the seeds.

The dry weights for seedlings grown in water also show a relation to size of seed. In the roots of seedlings, those from the small seeds of Density 3 nearly equal in average, minimum and maximum dry weights the roots from medium seeds of equal density. As between medium and large seeds, seedlings from medium seeds of Density 4 surpass those from the large seeds in minimum and average weight; and seedlings from medium seeds of Density 5 surpass those from large seeds in average and maximum dry root weight. In general, however, the weights of seedlings grown in water from seeds of equal densities vary as the size of the seed. The comparison of average dry plant weight is given graphically in Plate II.

Turning now to the data for average values in soil grown seedlings (Tables 37 to 39) we find that, except for the average weights of seedlings from medium seeds of Density 2, all average fresh weights vary as the size of the seeds provided they are equal in density. In the exception just cited the average weights for seedlings from medium seeds is greater than that for those of the larger seed in the case of root, shoot and plant weights. With but one exception,

again in Density 2, all dry root, shoot and plant weights vary as the size of the seeds provided we compare seedlings from seeds of the same density. Plate IV represents the average dry plant weights for soil grown seedlings.

Comparison of Weights.—In general, the percentage which the dry weight of shoot and plant is of the fresh weight of like member is greater for seedlings from the large seeds than from the medium or the small seeds. The percentage which the dry plant weight is of the seed weight is also higher for seedlings from the large seeds than from the medium or small seeds.

Rate of Growth.—That the rate of growth is also influenced by the size of the seed is shown by the daily growth increments. For water culture seedlings the average daily increments (Tables 18 to 20) on the second and third day are greater for the seedlings from medium seeds than for those of either small or large seeds of like density. The greatest average daily increments, except in seedlings from large seeds of Densities 1 and 2, are found in the seedlings from the medium seeds. The maximum daily increment occurs on the second day in seedlings from the small and the medium seeds but not until the third day for those from the large seeds. The same superiority in the rate of growth for seedlings from the medium seeds grown in soil is seen from Tables 37 to 39.

In so far as amount and rate of growth are influenced by the size of the seed, we find:

(1) The amount of growth varies with the size of the seed;

(2) There is more variation in amount of growth between small and medium seeds than between medium and large seeds;

(3) The rate of growth of seedlings from medium seeds is greater than that for those of small or large seeds of equal density.

3. Temperature in Relation to Specific Gravity and Size of Seed.

It is not the intention to discuss in detail growth at 20° and 30°C, but rather to determine whether conclusions

drawn for temperature 25° may be applied to seedlings from similar seeds grown at 20° and 30°C respectively. Because of the limited number of large seeds no data is available save at 25°C. The discussion will be confined to a consideration of average values. The data for seedlings grown at 20°C are found in *Tables 40 to 43, that for those grown at 30°C in *Tables 44 to 47.

a. Growth as Related to Specific Gravity.

A study of the above tables shows that with but few exceptions the conclusions drawn for the relation of growth to the specific gravity of the seed, for temperature 25°C are also true for temperatures 20° and 30°C. At 25°C there was no correlation evident between length of hypocotyl and specific gravity of seed; at 20°, however, the greatest average length of hypocotyl in seedlings grown in soil appear in those of Densities 1, 2 and 3.

At 25°C, the percentage of the dry plant weight to the seed weight is higher for seedlings from seeds of Density 6 than for those from seeds of Densities 1 and 2. At 20°C, this is true only for seedlings grown in water, and at 30°C, it applies solely to seedlings from medium seeds grown in water.

b. Growth as Related to Size of Seed.

The seedlings grown at 30°C show the same correlation between growth and size of seed as is shown by those grown at 25°C. For the seedlings grown at 20°C, however, the following points of difference seem evident:

(1) The average heights and average weights of seedlings from small seeds are more nearly equal to the similar average values of seedlings from medium seeds of like densities, at 20°C than at 25°C. In a few cases the average values for seedlings from small seeds exceed those for seedlings from medium seeds.

(2) From the total dry weight it may be inferred that at 20°C the seedlings from small seeds use their reserve material to better advantage than those from the medium seeds.

(3) At 20°C, the greater rate of growth is shown by seedlings from the small seeds.

4. Some Comparisons of Seedlings Grown in Water and Soil.

a. Water Content.—The relation of the dry weights to the fresh weights shows a difference in the relative water content of seedlings from seeds of equal size and density grown in water and soil. The percentage of the dry root weight to the fresh root weight is greater for the seedlings grown in soil; that of the dry shoot and plant weights to the fresh shoot and plant weight is greater for those grown in water.

The stems of the seedlings grown in soil were brittle while those grown in water could be coiled without breaking.

b. Roots.—The root system of the seedlings grown in soil was very much larger than that of seedlings grown in water. In the majority of the soil culture seedlings the primary root soon ceased to elongate and the main part of the root system consisted of several long, lateral roots arising from near the base of the main root. In the seedlings grown in water the primary root, although comparatively short, was the main part of the root system. Several short lateral roots developed near the base of the root and also lower down on the primary root.

5. Equation of Growth.

A study of the tables here recorded shows that the equation of growth given by Blackman, V. H. (1) does not apply to seedlings grown in the dark. In the case of each seedling grown under the conditions of these experiments the final dry weight is much less than the initial dry weight of the seed. This would mean, if Blackman's equation held true, that there had been no growth in these seedlings.

6. Correlation of Weight and Position of Cotyledons.

Harris (6), in an article on Interrelationships in Phaseolus, states that the green and dry weights of the primordial and first compound leaves of plants whose cotyledons are not inserted at the same level of the axis are less than those of normal plants. No such correlation exists for the fresh and dry weights of the seedlings recorded here. Numerous examples of this "abnormality" as Harris calls it, occurred

but no account was taken of them unless the difference in level was at least 2mm; in some exceptional cases it was as much as 18mm. That no such correlation exists in these seedlings is shown by a comparison of the root, shoot, and plant weights of an abnormal seedling with the corresponding average weights of the group to which it belongs. Such a comparison shows that the weights of the seedling are sometimes above and sometimes below the average weights.

7. Quintile Distributions.

An article by Pearl and Surface (14) on "Growth and Variation in Maize" states, on page 120, "There is, then, a marked tendency for the plants which were relatively small at the beginning of the season to have remained, on the average, relatively small throughout most of the season." Or, to quote further (page 170), "Extreme variants at the beginning of the season tend strongly, on the whole, to remain extreme variants during the whole season." This tendency is said to be due to the effect of internal rather than to external stimuli.

Reed, (15) in studying growth and variability in Helianthus, follows the method of argument of Pearl and Surface and concludes that, "Plants which started in a given quartile showed a well-marked tendency to remain in that quartile during the entire grand period of growth. Plants which were small at maturity were generally small from the beginning, those which were large at maturity had a well-marked superiority from the start." He, too, thinks plants show this tendency because of inherent factors.

In order to determine whether the seedlings used in the present experiments revealed similar traits the data for all seedlings which were grown in water and which were placed in the 25°C temperature case on the sixth day after placing them to germinate, were collected. A group of 75 seedlings containing individuals from seeds of all densities and sizes was thus obtained. The heights of these seedlings on each successive day and the density and size of the seeds from which each grew are given in *Table 49.

*It has been found necessary in the publication of these experiments to omit Tables 1-17, 21-36, 40-49. These tables can be found in the original thesis at the Library of the University of Illinois.

The seedlings are arranged and numbered according to their size on the first day, that is, on the day they were placed in the constant temperature case and six days after planting. Following the method given in the articles cited, these 75 seedlings are arranged in five groups, or quintiles, according to their size on the first day. In order to avoid having seedlings of the same size fall in two different quintiles, the number of plants in the quintiles varies. Thus, Quintile I contains the 15 smallest seedlings on each day of measurement. Quintile II contains the 16 next larger; Quintile III, the 17 next larger; Quintile IV, the 12 next; and Quintile V, the 15 largest ones. The number of seedlings in the respective quintiles was maintained during the growth period. In but two cases, after the initial distribution, did two seedlings fall on the separating line of contiguous quintiles. In these cases one of the seedlings was arbitrarily placed in the next highest quintile. The quintile distribution for each successive day for seedlings starting in the several quintiles is given in Tables 50 to 54. These tables give the total number of distributions, excluding those of the first day, when, of course, all distributions were in the particular quintile to which the seedlings were originally assigned, and also the mean quintile position for each day. A study of the tables shows that by the sixth day only 3 of the 15 seedlings which started in Quintile I are still in this quintile and by the tenth day only 2 remain. Three of the 15 reach Quintile V by the ninth day. Out of the total of 165 distributions only 42, or 25.5% are in Quintile I. The mean quintile position for these seedlings changes from 1 on the initial day to 3 on the eleventh and twelfth days. This final mean quintile position is above the general mean, which owing to the difference in the number of seedlings in the several quintiles is 2.95. Only 18.8% of the total number of distributions for seedlings starting in Quintile II fall in this quintile. For Quintile III the per cent is 20.9; for Quintile IV, it is 25; and for Quintile V, 25.5. The mean quintile position for seedlings starting in Quintile V drops from 5 on the first day to 2.87 on the ninth day. The curves for the mean quintile positions on the successive days are plotted in Plate V. As is to be expected where the variation can be in either

of two directions, there is a smaller shifting of the mean quintile positions in the intermediate quintiles than in Quintiles I and V. From the preceding facts it appears that seedlings which are small at first frequently surpass in growth, larger ones of equal age.

Let us consider now the specific gravity and the size of the seeds from which these 75 seedlings grew. Of the 15 seedlings which started as the smallest, Quintile I, (Table 50), 7 are from small seeds, 1 from a medium and 7 from large seeds. The 2 seedlings which remain in Quintile I on the last day are from small seeds, the 4 in Quintile II are likewise from small seeds. The seventh seedling from small seeds which started in Quintile I is from a seed of Density 3 and is the smallest seedling of Quintile III. Of the 3 seedlings which, starting in Quintile I, reach Quintile V, all are from large seeds; the 2 largest in this case, are from seeds of Density 3, the third from a seed of Density 5. The 2 seedlings in Quintile IV are also from large seeds. The seedling from the medium seeds is in Quintile III. Of the 16 seedlings which start in Quintile II (Table 51), 10 are from small, 5 from medium and 1 from large seeds. The 6 seedlings which fall back into Quintile I are all from small seeds. The 1 which reaches Quintile IV is from a large seed. In Quintile III, (Table 52), 7 of the original 17 are from small, 8 are from medium and 2 from large seeds. The 3 seedlings which, starting in Quintile III recede to Quintile I, are from small seeds. The 4 ending in Quintile II are also from small seeds. Of the 5 which end in Quintile V, 1 is from a large seed, the other 4 from medium seeds. The second seedling from large seeds starting in Quintile III falls just below Quintile V. All of the seedlings which start in Quintile IV (Table 53) are from medium seeds. Of the 5 which reach Quintile V, 2 are from seeds of Density 1 and 3 from those of Density 3. Ten of the 15 seedlings which start in Quintile V, (Table 54), are from medium seeds, the other 5 are from small seeds. On the last day, 3 of those from small seeds are the seedlings in Quintile I, the other 2 are in Quintile II. Of those which remain in Quintile V, 1 is from a medium seed of Density 1, the other is from a medium seed of Density 3.

Out of the 75 seedlings in the group in question, 29 are from small, 36 from medium and 10 from large seeds. Of the 29 seedlings from small seeds, regardless of their position on the first day, 14 are in Quintile I, 14 are in Quintile II and 1 is in Quintile III on the last day. The final distribution of the seedlings from the large seeds is 4 in Quintile V, 4 in Quintile IV and 2 in Quintile III. From the foregoing statements the following conclusions seem justified:

(1) Seedlings which are small at first frequently surpass in growth, larger ones of equal age;

(2) The size and specific gravity of the seeds, chiefly the former, are more definitely correlated with growth than is the initial height of seedlings of the same age.

SUMMARY

Common garden bean seed was separated into 6 groups of different densities by the use of sodium nitrate of 1.32, 1.27, 1.22, 1.17, and 1.12 specific gravity. The seeds of each of the densities were then grouped according to length into small, medium and large.

Seedlings from seeds of each size and density were grown in the dark at 25°C. Seedlings from small and medium seeds of each density were also grown in the dark at 20° and 30°.

Daily measurements were taken and from this data the daily growth increments were determined. When growth ceased both the fresh and the dry weight of the seedling was obtained.

A study of the results made evident that:

(1) Seedlings grown from seeds of 1.32, 1.27, 1.22, 1.17, 1.12 and 1.12–specific gravity differ in amount and rate of growth.

(2) The greatest height and diameter of shoot, also the greatest dry weight, for seedlings from seeds of uniform size is found in those grown from seeds of 1.22, 1.27 and 1.32 specific gravity, seeds of 1.22 or 1.27 usually ranking first.

(3) The greatest fresh weight is, in general, found in seedlings grown from seeds of 1.32, 1.27 and 1.22 specific gravity.

(4) The lower and specific gravity of the seed, the shorter the second and third internodes of the seedlings from seeds of equal size.

(5) The greatest rate of growth, for seedlings from seeds of uniform size, is usually found in seedlings from seeds of 1.32, 1.27 or 1.22 specific gravity.

(6) From the total dry weight it may be inferred that at 25°C the seedlings from seeds of Density 6 use their reserved material to the best advantage.

(7) Seedlings grown from small, medium and large seeds differ in amount and rate of growth.

(8) The total amount of growth varies directly with the length of the seed.

(9) Size and weight of seedlings from seeds of uniform specific gravity show a wider variation (more especially at 25°C) between those from small and medium seeds than between the ones from medium and large.

(10) Seedlings from seeds of medium length show a greater growth rate than seedlings from either small or large seeds of equal specific gravity.

(11) From the total dry weight it may be inferred that, except at 20°C, seedlings from the large and medium seeds use their reserve material to better advantage than those from small seeds.

(12) Seedlings grown in water contain a smaller per cent of water than those from seeds of the same specific gravity and size grown in soil. They are also less brittle.

(13) The root system of seedlings grown in soil is larger than that of seedlings grown in water.

(14) The growth equation of Blackman does not apply to seedlings grown in the dark.

(15) A difference in level in the insertion of the cotyledons on the axis is not correlated with the fresh and dry weights of either root, shoot or plant.

(16) Seedlings which are small at first frequently surpass in growth larger ones of equal age.

(17) The size and specific gravity of the seeds are more definitely correlated with growth than is the initial height of seedlings of the same age.

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TABLE 18.

Series A — WATER CULTURE — SMALL SEEDS — Temperature 25° C

Average Daily Growth Increments in Centimeters

Density	IH	1	2	3	4	5	6	7	8	9	10	11	TH
HYPOCOTYL													
1	1.83	1.62	3.90	3.30	.43	.01							11.09
2	1.85	4.06	4.47	1.53	.21								12.11
3	1.29	3.59	4.12	1.45	.20								10.65
4	1.47	2.03	4.73	2.38	.30	.04							10.95
5	1.50	2.17	4.17	2.56	.71	.11							11.23
6	1.25	3.07	5.23	2.27	.33	.02							12.17
FIRST INTERNODE													
1		.26	.47	1.63	3.45	3.13	1.59	.45	.16	.01			11.15
2		.40	.77	1.84	3.68	2.94	1.56	.56	.19	.01			11.95
3		.36	.75	2.34	3.60	2.86	1.29	.40	.15				11.75
4		.28	.50	1.54	3.96	3.11	1.66	.53	.25	.01			11.84
5		.24	.36	1.13	2.81	2.90	1.84	.70	.10	.03			10.11
6		.27	.59	1.58	3.30	2.63	1.32	.50	.13	.07			10.37
SECOND INTERNODE													
1				.04	.10	.16	.21	.41	.35	.25	.08	.05	1.65
2				.04	.15	.05	.13	.20	.29	.07	.01		.94
3				.10	.15	.06	.17	.30	.20	.08	.03	.01	1.10
4				.08	.10	.09	.10	.16	.18	.18	.02		.91
5				.03	.10	.13	.08	.16	.17	.19	.13	.03	1.01
6					.10	.15	.02	.08	.08	.05			.48
THIRD INTERNODE													
1							.01	.01	.05	.01			.08
2								.01	.03	.03			.06
3							.01	.03	.01			.01	.06
4									.01	.04	.01		.06
5									.01	.03			.04
6									.02				.02
SHOOT													
1	1.83	1.89	4.37	4.96	3.98	3.30	1.81	.88	.56	.27	.07	.05	23.97
2	1.85	4.45	5.25	3.40	4.04	2.99	1.69	.77	.50	.11	.01		25.06
3	1.29	3.95	4.87	3.88	3.95	2.93	1.47	.72	.36	.08	.03	.03	23.56
4	1.47	2.30	5.24	3.99	4.36	3.24	1.76	.69	.45	.24	.04		23.78
5	1.50	2.41	4.52	3.71	3.63	3.14	1.93	.86	.29	.24	.13	.03	22.40
6	1.25	3.33	5.80	3.85	3.74	2.80	1.34	.58	.23	.08			23.00

Density	Average Wt. of Seed (gram)	Average Length (mm) of Seed	Average Fresh Weight in grams of Root	Shoot	Plant	Average Dry Weight In grams of Root	Shoot	Plant	Average Diam. (mm)
1	.2666	10.7	.3269	1.3860	1.7069	.0170	.1010	.1180	2.6
2	.2581	10.8	.3318	1.3084	1.6402	.0184	.0941	.1125	2.7
3	.2757	10.8	.3648	1.3596	1.7244	.0196	.0902	.1188	2.7
4	.2526	10.4	.3197	1.2845	1.6042	.0164	.0931	.1095	2.6
5	.2227	10.5	.3024	1.1356	1.4380	.0157	.0839	.0996	2.5
6	.1713	10.1	.2212	.9623	1.1835	.0124	.0657	.0781	2.3

IH—Height when placed in temperature case. TH—Total height.

TABLE 19.

Series B — WATER CULTURE — MEDIUM SEEDS — Temperature 25°C

Density — Average Daily Growth Increments in Centimeters

Density	IH..	1	2	3	4	5	6	7	8	9	10	11	12	TH
HYPOCOTYL														
1	1.94	4.32	5.35	1.84	.10									13.55
2	2.25	4.60	4.58	2.14	.07									13.64
3	1.84	5.50	6.33	1.34	.05									15.05
4	1.86	4.21	5.24	.94	.09									12.34
5	1.43	2.10	6.59	3.44	.87	.01	.06							14.47
6	1.84	3.27	6.17	3.06	.53	.11								14.99
FIRST INTERNODE														
1		.44	.84	2.99	4.17	2.52	.84	.16						11.96
2		.40	.66	2.29	4.61	3.85	1.60	.51	.15					14.08
3		.44	1.28	2.90	4.05	2.51	.94	.30	.06	.02	.02			12.50
4		.51	1.10	3.74	3.85	1.53	.63	.25	.06					11.66
5		.33	.51	1.81	4.16	4.67	2.64	.97	.34	.06	.01			15.51
6		.33	.57	1.81	5.24	3.70	1.51	.63	.24	.01				14.06
SECOND INTERNODE														
1				.15	.31	.01	2.36	2.98	1.19	.41	.10	.05		8.46
2				.06	.18	.21	.42	1.24	1.53	.52	.10			4.26
3			.04	.16	.20	.66	2.23	1.84	1.14	.42	.06	.01		6.76
4			.18	.14	.16	.84	.98	.73	.36	.21	.05			3.64
5				.01	.04	.20	.23	.40	.57	.36	.23	.16		2.20
6				.01	.09	.24	.40	.47	.54	.49	.24	.07	.06	2.61
THIRD INTERNODE														
1							.15	.25	.15	.14	.10	.05		.84
2								.04	.16	.08				.28
3							.11	.15	.16	.18	.08	.05		.73
4								.05	.08	.05	.03			.20
5										.04	.01	.04		.10
6								.03	.01	.04	.03	.01	.01	.14
FOURTH INTERNODE														
3										.05	.01			.06
SHOOT														
1	1.94	4.76	6.19	4.97	4.59	3.44	3.35	3.39	1.34	.55	.20	.10		34.81
2	2.25	5.00	5.34	4.49	4.86	4.06	2.02	1.79	1.84	.60	.10			32.25
3	1.84	5.94	7.63	4.40	4.30	3.18	3.28	2.29	1.36	.67	.15	.06		35.10
4	1.86	4.73	6.33	4.85	4.08	1.69	1.46	1.27	.86	.41	.24	.05		27.83
5	1.43	2.43	7.10	5.27	5.07	4.89	2.90	1.37	.91	.46	.26	.20		32.29
6	1.84	3.60	6.74	4.89	5.86	4.06	1.91	1.13	.80	.54	.27	.09	.07	31.80

	Average Wt. & Length of Seed (gram)	(mm)	Average Fresh Weight in grams of Root	Shoot	Plant	Average Dry Weight In grams of Root	Shoot	Plant	Average Diam. (mm)
1	.4407	13.7	.3495	2.1925	2.5420	.0239	.1715	.1954	3.1
2	.3851	12.9	.3240	1.8985	2.2225	.0199	.1492	.1691	2.9
3	.3915	13.5	.3602	2.0435	2.3437	.0197	.1519	.1716	3.0
4	.3134	13.1	.3501	1.6348	1.9849	.0191	.1164	.1355	2.8
5	.3290	13.1	.3259	1.6671	1.9930	.0195	.1216	.1411	2.9
6	.2915	13.3	.3139	1.5851	1.8990	.0169	.1148	.1317	2.7

TABLE 20

Series C — WATER CULTURE — LARGE SEEDS — Temperature 25°C

Average Daily Growth Increments in Centimeters

Density	IH	1	2	3	4	5	6	7	8	9	10	11	12	TH
HYPOCOTYL														
1	1.80	2.40	5.65	2.25	.05									12.15
2	1.87	2.93	5.13	2.33	.10									12.37
3	1.13	1.37	3.47	3.97	2.33	.22								12.48
4	1.10	2.05	4.92	4.33	1.08	.10								13.58
5	1.70	3.00	4.40	3.63	.83									13.55
FIRST INTERNODE														
1		.40	1.15	4.35	4.15	2.25	..70	.15						13.15
2		.43	.85	3.73	4.25	3.18	.62	.12						13.18
3		.30	.33	.72	2.77	4.95	3.22	.97	.28	.03				13.57
4		.28	.27	1.23	2.75	4.47	3.17	.80	.15					13.12
5		.30	.35	1.25	3.00	4.70	2.90	.50	.13					13.13
SECOND INTERNODE														
1			.25	.30	1.20	3.70	2.70	1.05	.35	.15				9.70
2				.30	.45	1.52	3.90	2.38	.68	.13				9.37
3				.03	.15	.40	1.20	2.67	2.13	.82	.38	.12		7.90
4					.12	.30	.65	1.80	1.55	.58	.42	.18		5.60
5					.08	.37	.75	1.38	1.30	.63	.15	.05	.02	4.93
THIRD INTERNODE														
1						.35	.15	.25	.20	.15	.10	.15	.10	1.15
2						.12	.28	.37	.28	.08	.03			1.17
3							.12	.18	.18	.15	.08	.02		.73
4								.12	.12	.03	.07	.03		.37
5								.10	.15	.08	.10	.02		.45
FOURTH INTERNODE														
1													.05	.05
SHOOT														
1	1.80	2.80	6.80	6.85	4.50	3.50	4.55	3.10	1.25	.50	.25	.15	.15	36.30
2	1.87	3.37	5.98	6.37	4.80	4.82	4.80	2.87	.97	.18	.07			36.08
3	1.13	1.66	3.80	4.71	5.25	5.56	4.57	3.81	2.62	1.03	.46	.13		34.73
4	1.10	2.32	5.20	5.55	3.95	4.88	3.82	2.73	1.82	.60	.50	.20		32.68
5	1.70	3.30	4.75	4.88	3.90	5.07	3.65	2.18	1.57	.70	.25	.10	.02	32.07

	Average Wt. of Seed (gram)	Average Length (mm)	Average Fresh Weight in grams of Root	Shoot	Plant	Average Dry Weight In grams of Root	Shoot	Plant	Average Diam. (mm)
1	.4057	16.2	.5499	2.4527	3.0026	.0295	.1872	.2167	3.3
2	.5272	16.1	.6445	2.5433	3.1878	.0331	.2059	.2391	3.5
3	.5174	16.9	.3644	2.6313	2.9957	.0271	.2099	.2370	3.5
4	.3966	15.8	.3347	2.1359	2.4706	.0193	.1629	.1822	3.1
5	.4147	15.3	.2699	2.1988	2.4687	.0189	.1699	.1888	3.2

TABLE 37

Series D — **SOIL CULTURE** — **SMALL SEEDS**

Temperature 25°C

Density	IH	Average Daily Growth Increments in Centimeters 1	2	3	4	5	6	7	8	9	10	11	TH
						HYPOCOTYL							
1	1.63	2.40	5.37	5.08	.26								14.76
2	2.11	3.70	5.60	.98	.04								12.43
3	2.26	3.55	4.61	1.74	.10								12.26
4	2.11	2.79	6.55	2.75	.14								14.34
5	1.29	2.58	5.71	4.13	.37								14.08
6	2.36	3.26	5.70	1.89	.06								13.27
						FIRST INTERNODE							
1		.23	.53	2.31	3.94	1.77	.51	.14	.03				9.47
2		.45	1.38	3.05	2.58	.84	.25	.07					8.62
3		.41	1.11	2.59	2.49	1.18	.32	.08	.01				8.19
4		.31	.91	2.85	3.29	1.14	.21	.08	.01				8.80
5		.24	.53	1.56	2.99	2.02	.46	.15					7.95
6		.36	.76	2.61	2.94	1.06	.17	.03					7.91
						SECOND INTERNODE							
1				.16	.18	.26	.57	.49	.21				1.87
2			.11	.17	.14	.30	.50	.24	.06	.01			1.54
3			.01	.11	.18	.14	.18	.16	.05	.01			.84
4			.03	.14	.19	.21	.35	.16	.06	.01	.01		1.16
5				.09	.12	.09	.05	.10	.01	.01	.01		.48
6			.11	.16	.16	.13	.10						.66
						THIRD INTERNODE							
1							.03	.04	.03				.10
2							.04	.04	.01	.01			.10
3							.03	.01					.04
4							.01	.04	.01				.06
5												.01	.01
6								.03					.03
						SHOOT							
1	1.63	2.64	5.90	7.56	4.38	2.03	1.11	.67	.27				26.20
2	2.11	4.15	7.10	4.20	2.75	1.14	.79	.35	.08	.02			22.69
3	2.26	3.96	5.74	4.44	2.76	1.31	.53	.25	.06	.01			21.32
4	2.11	3.10	7.49	5.74	3.61	1.35	.58	.27	.09	.01	.01		24.36
5	1.29	2.81	6.24	5.77	3.49	2.11	.51	.25	.01	.01	.01	.01	22.51
6	2.36	3.61	6.46	4.61	3.14	1.21	.30	.16					21.85

	Average Wt. & Length of Seed (gram)	(mm)	Average Fresh Weight in grams of Root	Shoot	Plant	Average Dry Weight In grams of Root	Shoot	Plant	Average Diam. (mm)
1	.2881	11.0	.3424	1.6683	2.0107	.0200	.1091	.1291	2.8
2	.2665	10.7	.3252	1.5319	1.8571	.0219	.0994	.1213	2.8
3	.2444	10.8	.2609	1.4573	1.7182	.0190	.0907	.1097	2.7
4	.2429	10.5	.2203	1.4990	1.7193	.0163	.0937	.1100	2.5
5	.2164	10.3	.1504	1.2380	1.3884	.0148	.0801	.0949	2.5
6	.1983	10.8	.1343	1.1577	1.2920	.0157	.0762	.0919	2.4

TABLE 38

Series E — SOIL CULTURE — MEDIUM SEEDS — Temperature 25°C

Average Daily Growth Increments in Centimeters

Density	IH	1	2	3	4	5	6	7	8	9	10	11	TH
HYPOCOTYL													
1	2.84	4.39	6.27	1.70									15.20
2	2.67	4.37	5.96	1.99	.27								15.26
3	2.29	3.53	8.11	4.07	.19								18.19
4	2.54	3.21	7.03	2.86	.15								15.79
5	2.10	3.21	8.03	3.67	.39	.04							17.44
6	3.14	5.04	6.48	.68	.04								15.38
FIRST INTERNODE													
1		.41	1.31	3.24	2.91	1.21	.49	.15					9.73
2		.44	1.51	3.23	3.06	.67	.27	.07					9.26
3		.29	.79	3.19	3.88	1.89	.56	.17	.01				10.78
4		.40	1.06	3.40	3.14	1.13	.42	.15					9.70
5		.33	.80	2.74	4.30	2.27	.40	.11	.03				10.99
6		.62	1.54	4.30	3.12	.92	.26	.06	.04				10.86
SECOND INTERNODE													
1			.03	.22	.29	.85	2.13	1.40	.19	.07			5.18
2			.03	.27	.34	.93	1.46	.86	.26	.01			4.16
3				.20	.36	.51	1.11	1.03	.31	.19	.03		3.74
4				.24	.23	.32	.84	.60	.20	.01			2.44
5				.13	.23	.37	.56	.79	.31	.03	.01		2.43
6			.04	.18	.30	.40	.44	.40	.20	.06			2.02
THIRD INTERNODE													
1							.13	.18	.01	.01			.33
2						.03	.09	.07	.04	.04			.27
3								.05	.09	.07			.21
4								.04	.04	.03			.10
5								.04	.01	.01	.01		.07
6									.02	.02			.04
SHOOT													
1	2.84	4.80	7.61	5.16	3.20	2.06	2.74	1.73	.20	.09			30.43
2	2.67	4.81	7.50	5.49	3.67	1.63	1.81	1.00	.30	.06			28.94
3	2.29	3.81	8.90	7.46	4.43	2.40	1.68	1.25	.41	.26	.02		32.91
4	2.54	3.61	8.09	6.46	3.53	1.44	1.26	.81	.25	.04			28.03
5	2.10	3.54	8.83	6.54	4.91	2.69	.96	.94	.36	.04	.03		30.94
6	3.14	5.66	8.06	5.16	3.46	1.32	.70	.46	.36	.08			28.30

	Average Wt. & Length of Seed (gram)	(mm)	Average Fresh Weight in grams of Root	Shoot	Plant	Average Dry Weight In grams of Root	Shoot	Plant	Average Diam. (mm)
1	.4176	13.3	.4172	2.3848	2.8020	.0294	.1630	.1924	3.3
2	.4215	13.3	.4485	2.5520	3.0005	.0327	.1659	.1986	3.2
3	.3579	13.3	.3072	2.4495	2.7567	.0228	.1407	.1635	3.1
4	.3354	13.0	.3574	2.0892	2.4466	.0266	.1293	.1559	3.1
5	.3334	13.2	.2886	2.0904	2.3790	.0235	.1288	.1523	3.0
6	.3072	13.4	.5046	1.9502	2.4548	.0294	.1206	.1500	3.0

TABLE 39

Series F — SOIL CULTURE — LARGE SEEDS — Temperature 25°C

Average Daily Growth Increments in Centimeters

Density	IH	1	2	3	4	5	6	7	8	9	10	11	TH
						HYPOCOTYL							
2	2.17	3.17	5.90	2.07	.11								13.42
3	2.22	2.75	5.25	3.60	.27								14.08
4	2.93	5.07	4.83	.53									13.36
5	2.53	3.33	6.25	2.60	.18								14.90
						FIRST INTERNODE							
2		.53	1.67	3.99	3.53	1.14	.44	.14	.03	.01			11.48
3		.33	.80	2.65	4.63	2.50	.67	.15					11.73
4		.63	2.23	3.63	2.83	1.03	.23	.13					10.73
5		.38	1.08	3.35	3.70	1.32	.18	.07	.02				10.10
						SECOND INTERNODE							
2			.10	.27	.49	1.39	1.49	.54	.19	.04			4.50
3				.15	.33	.92	2.33	1.77	.45	.03			5.98
4			.03	.23	.47	.83	.90	.43	.07				2.97
5				.27	.40	.63	1.12	.43	.20	.01			3.06
						THIRD INTERNODE							
2						.04	.13	.07	.03	.03			.30
3						.05	.10	.15	.07				.37
4						.03	.07	.03	.07				.20
5						.12	.02	.05					.18
						SHOOT							
2	2.17	3.70	7.67	6.33	4.13	2.57	2.06	.76	.24	.09			29.71
3	2.22	3.08	6.05	6.40	5.23	3.47	3.10	2.10	.52	.03			32.17
4	2.93	5.70	7.10	4.40	3.30	1.90	1.20	.00	.13				27.27
5	2.53	3.72	7.33	6.22	4.28	1.95	1.42	.52	.27				28.25

Density	Average Wt. & Length of Seed (gram)	(mm)	Average Fresh Weight in grams of Root	Shoot	Plant	Average Dry Weight In grams of Root	Shoot	Plant	Average Diam. (mm)
2	.4421	15.6	.2043	2.4114	2.6157	.0287	.1719	.2006	3.4
3	.4658	16.2	.4839	2.7125	3.1964	.0360	.1904	.2264	3.3
4	.4162	15.7	.6050	2.5739	3.1790	.0310	.1718	.2028	3.3
5	.3887	15.6	.3402	2.3250	2.6652	.0260	.1585	.1845	3.1

The cost of printing necessitates the omission of the data from which the following tables are derived:

TABLE 50

Quintile Distribution on Successive Days for Seedlings Starting on Quintile I.

Quintile	1	2	3	4	5	6	7	8	9	10	11	12	Total*
I	15	8	8	5	4	3	2	3	3	2	2	2	42
II	0	6	6	7	7	6	5	5	4	5	4	4	59
III	0	1	0	2	4	4	5	3	3	3	4	4	33
IV	0	0	0	1	0	2	2	2	2	2	2	2	15
V	0	0	1	0	0	0	1	2	3	3	3	3	16
												Grand Total	165

Mean Quintile Position

1.00 1.53 1.67 1.93 2.00 2.33 2.67 2.67 2.87 2.93 3.00 3.00

TABLE 51

Quintile Distribution on Successive Days for Seedlings Starting on Quintile II.

Quintile	1	2	3	4	5	6	7	8	9	10	11	12	Total*
I	0	5	4	7	7	6	6	6	6	6	6	6	65
II	16	3	4	1	1	3	3	2	4	4	4	4	33
III	0	8	7	7	6	4	4	6	4	5	5	5	61
IV	0	0	1	1	1	3	3	2	2	1	1	1	16
V	0	0	0	0	1	0	0	0	0	0	0	0	1
												Grand Total	176

Mean Quintile Position

2.00 2.19 2.31 2.13 2.25 2.25 2.25 2.25 2.13 2.06 2.06 2.06

TABLE 52

Quintile Distribution on Successive Days for Seedlings Starting on Quintile III.

Quintile	1	2	3	4	5	6	7	8	9	10	11	12	Total*
I	0	2	1	2	3	4	3	3	3	3	3	3	30
II	0	5	5	5	4	2	4	4	3	3	4	4	43
III	17	7	5	2	1	4	3	3	4	4	3	3	39
IV	0	3	5	5	6	1	2	2	2	2	2	2	32
V	0	0	1	3	3	6	5	5	5	5	5	5	43
												Grand Total	187
Mean Quintile Position													
	3.00	2.65	3.00	3.12	3.12	3.18	3.12	3.12	3.18	3.18	3.12	3.12	

TABLE 53

Quintile Distribution on Successive Days for Seedlings Starting on Quintile IV.

Quintile	1	2	3	4	5	6	7	8	9	10	11	12	Total*
I	0	0	1	1	1	0	2	1	1	1	1	1	10
II	0	2	0	0	1	2	0	1	1	1	1	1	10
III	0	1	3	2	2	2	1	1	1	1	1	1	16
IV	12	4	1	3	2	2	2	3	4	4	4	4	33
V	0	5	7	6	6	6	7	6	5	5	5	5	63
												Grand Total	132
Mean Quintile Position													
	4.00	4.00	4.08	4.09	3.92	4.00	4.00	4.00	3.92	3.92	3.92	3.92	

TABLE 54

Quintile Distribution on Successive Days for Seedlings Starting on Quintile V.

Quintile	1	2	3	4	5	6	7	8	9	10	11	12	Total*
I	0	0	0	0	0	2	2	2	2	3	3	3	17
II	0	0	2	3	3	3	4	4	4	3	3	3	32
III	0	0	2	4	4	3	4	4	5	4	4	4	38
IV	0	5	5	2	3	4	3	3	2	3	3	3	36
V	15	10	6	6	5	3	2	2	2	2	2	2	42
												Grand Total	165
Mean Quintile Position													
	5.00	4.67	4.00	3.73	3.67	3.20	2.93	2.93	2.87	2.87	2.87	2.87	

*Total distribution exclusive of first day.

SUMMARY OF THE PAPER ENTITLED

"A METRICAL STUDY OF A THOUSAND MOTH COCOONS."

PROF. ELLIOT R. DOWNING, UNIVERSITY OF CHICAGO

* * * * *

In the autumn of 1916, the cocoons of the Cecropia and Polyphemus moths were very numerous in the southwestern portion of Chicago. Two hundred forty-eight Cecropia cocoons were counted on one small catalpa tree on a lawn in Roseland. A small hickory about two feet high, found growing on the open prairie near the city limits, was so plastered with cocoons that no stem or branch was visible.

There were two centers of abundance; one in Roseland; the other in the neighborhood of the B. & O. railroad crossing at 91st street. These centers had apparently been populated by the moths from a common point in the neighborhood of Chicago Heights where the moths had been especially abundant the preceding year. The direction of migration from this original center had been determined apparently by the prevailing winds.

In the fall of 1916, some eighteen hundred Polyphemus cocoons and forty-two hundred Cecropia cocoons were collected in the two regions mentioned. Since then, collections have been made annually for the purpose of comparison with the first lot. In 1916, five hundred cocoons each of the Cecropia and Polyphemus were taken at random from the thousands collected to make a careful study of the cocoons and moths that were hatched from them. Similar samplings have been made each succeeding year, though in decreasing numbers since the cocoons are becoming scarce. The results of the study may be briefly stated as follows:

1st—The percentage of parasitized and diseased pupae has increased steadily during this period of five years, until now, the season of 1920-21, it is next to impossible to find a viable cocoon. In 1916, about one per cent of the

cocoons were parasitized, and thirty per cent dead through fungus disease.

2nd—In both moths, the lightweight cocoons produce males; the heavy cocoons, females. Thus, out of the thirty heaviest Cecropia cocoons, no males were produced; and out of the heaviest fifty, only five males. Out of the lightest thirty, nine females came; out of the lightest fifty, seventeen. The proportion of males to females in the whole lot was fifteen males to thirteen females.

3rd—Males were much more subject to death through fungus disease than females.

4th—The cocoons were kept indoors in a warm basement from the time of collection in November until they hatched in the following spring. The time of the appearance of the moth from the cocoon was about a month earlier than control cocoons left outdoors during the winter.

5th—The correlation between the weight of the pupa and the weight of the silk in both Cecropia and Polyphemus cocoons is low, and that between the weight of the pupa and the weight of the moth is still lower.

6th—There is a fairly close correlation between the weight of the pupa and its loss of weight in emerging from the cocoon.

7th—Males lose a much larger proportion of their pupa weight in transforming into moths than do females.

8th—Cecropia is much more variable in the weight of both pupa and silk than is Polyphemus.

9th—Cecropia is much more subject to parasitization than is polyphemus, at least in those stages examined. It may be that the Polyphemus larvae are killed by parasites before the cocoon is made.

THE AGRICULTURAL SIGNIFICANCE OF THE TIGHT CLAY SUBSOIL OF SOUTHERN ILLINOIS

PROF. R. S. SMITH AND F. A. FISHER*
ILLINOIS AGRICULTURAL EXPERIMENT STATION

The upland prairie soils of 27 counties in southern Illinois, as well as considerable areas in other states located in the Glacial and Loessial Province, among which are Iowa, northern Missouri, and southern Indiana, have an impervious subsoil known as "tight clay." The exact nature of this impervious stratum, which averages from 8 to 12 inches thick, and lies at a depth of about 17 inches, has not been determined. Its impervious nature is probably due to a high inorganic colloidal content. The comparatively low agricultural value of this section of the state is due to the presence of the tight clay, because of its interference with underdrainage. The economic importance as well as the scientific interest of the problem presented by the presence of this unfavorable substratum is apparent, and the discovery of a method of ameliorating the unfavorable condition would in time add very greatly to the resources of the state as well as to the resources of similar sections in adjoining states.

The causes of this formation, so far as the writer is aware, are not well understood. One theory accounts for it on the assumption that the percolating water carried the fine particles down from the surface soil and deposited them in the subsoil. This theory does not account for the failure of this substratum to form excepting in limited areas in glaciated sections farther north in the state. The formation is apparently associated with a high water table. It is found to occur in the bottom lands and terraces as well as in the prairie uplands in practically every portion of the state, but only locally in the northern two-thirds, while it occurs almost universally in the prairie soils of the southern third, which comprises the area covered by the lower Illinoisan glacial lobe.

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*Mr. Fisher is now Farm Adviser in Wabash County, Illinois.

The recognition of the fact that a soil's response to tillage and fertilizer treatments is never satisfactory when poor drainage conditions exist led the Illinois Experiment Station to lay out four series of four tenth-acre plots each in Cumberland county in 1913 on an area typical of this type. Ground limestone was applied to all plots in the fall of 1913 at the rate of 4 tons to the acre, and finely ground rock phosphate was applied the following spring at the rate of 1 ton to the acre. The application of limestone is to be repeated every 4 years at the rate of 2 tons to the acre, and rock phosphate at the rate of 1 ton to the acre. A rotation of corn, soybeans, wheat, and sweet clover is used, and all residues are returned. The series which is to go in corn is plowed late in the fall, Plot one 5 inches deep, Plot two is subsoiled 12 to 14 inches deep, Plot three is plowed 12 to 14 inches deep with a Spalding deep tillage machine, and Plot four is dynamited and afterwards plowed 5 inches deep. The charges of dynamite are placed in the impervious stratum eight feet three inches apart each way on the dynamited plots of the first two series, and eleven feet apart each way on the dynamited plots of series three and four.

The moisture conditions are such that the soil in this section is supersaturated in the spring due to the impervious nature of the tight clay substratum. It was thought that if the tillage treatments or the dynamiting had remedied this condition, it should be reflected in a lower moisture content of the surface and subsurface strata during this period of supersaturation. Moisture equivalent determinations had previously been made and the plots found to be uniform in this regard.

Early in the spring of 1919, a preliminary series of ten borings per plot were taken from Plots 4, 7, 10, and 13. The samples were taken from systematically distributed points in four depths, as follows: 0 to 6, 7 to 12, 13 to 18, and 19 to 24 inches. The percentages of moisture found in the individual samples were averaged in groups of ten, five and three, for the purpose of computing the probable error of the averages as a means of determining the number

of borings per plot necessary to get a representative average. The following formula was used for computing the probable error of the average.

$$\text{P. E.} = (-)0.8453 \frac{\Sigma(-)(V)}{\sqrt{n(n-1)}}$$

In which $\Sigma(-)(V)$ = the sum of the deviations from the mean, their sign being disregarded

n = number of borings entering the average.

It was at once found by inspection that three borings per plot were an insufficient number to give a reliable average, and the possibility of using this small number was at once abandoned. Tables 1 and 2 give the data secured in this preliminary work.

It will be noted that in Plot 4 the highest probable error occurred in the 7 to 12 inch borings, in Plot 7 in the surface borings, and in Plots 10 and 13 in the 19 to 24 inch borings. No explanation is apparent for the high variation found in the above named strata in Plots 4 and 7. In the case of Plots 10 and 13, the wide variations found in the moisture content of the 19 to 24 inch borings seem to be accounted for by the fact that the tight clay stratum does not occur at a uniform depth, and consequently some borings contained more of this material than others. This conclusion led to the abandonment of this plan of taking the borings at these arbitrary depths and the substitution, in all subsequent work, of the following depths: Surface, 0-8 inches, subsurface, 8 inches to the tight clay, subsoil, 6 inches of tight clay. These depths were chosen because they coincided with the very typical strata as they occur in this field.

During the spring of 1919, six sets of samples of 5 borings per plot were taken from Plots 1, 2, 3, and 4 of Series 100 and Plots 13, 14, 15, and 16 of Series 400. Series 100 had been plowed the preceding fall for corn and was undisturbed the following spring due to being too wet, until just prior to taking the last set of samples on June 19.

The plots of this series had received two tillage and dynamite treatments prior to this season's sampling, the first in the fall of 1914 and the second in the fall of 1918. Ap-

Table 1. Average Percent of Moisture, 10 Borings Per Plot. 1919.

Strata	Plot 4	Plot 7	Plot 10	Plot 13
0 - 6	30.8 (—) 0.48	29.6 (—) 0.36	27.4 (—) 0.79	30.9 (—) 0.23
7 - 12	29.4 (—) 0.67	28.3 (—) 0.30	25.2 (—) 0.71	28.7 (—) 0.27
13 - 18	28.5 (—) 0.58	26.3 (—) 0.26	26.0 (—) 0.72	27.7 (—) 0.38
19 - 24	30.4 (—) 0.57	27.2 (—) 0.35	29.6 (—) 0.83	31.6 (—) 0.67
Average 0 - 24	29.8 (—) 0.29	25.4 (—) 0.16	27.0 (—) 0.38	29.7 (—) 0.21

Note.—In this, and in all subsequent tables, the probable error is indicated by a dash in parenthesis, thus (—), instead of the plus and minus signs, as is customary.

Table 2. Average Percent of Moisture, 5 Borings Per Plot. 1919
Odd and Even Borings Averaged

Strata	Plot 4		Plot 7		Plot 10		Plot 13	
	Odd	Even	Odd	Even	Odd	Even	Odd	Even
0 - 6	31.0 (—) 0.76	30.7 (—) 0.63	30.1 (—) 0.62	29.4 (—) 0.35	27.0 (—) 0.55	27.8 (—) 0.23	30.9 (—) 0.20	30.8 (—) 0.43
7 - 12	30.2 (—) 0.84	28.7 (—) 0.98	28.7 (—) 0.33	27.7 (—) 0.55	25.1 (—) 0.98	25.3 (—) 0.52	28.6 (—) 0.32	28.1 (—) 0.57
13 - 18	28.7 (—) 1.00	28.4 (—) 0.74	27.0 (—) 0.41	25.8 (—) 0.38	24.7 (—) 0.84	25.3 (—) 1.00	28.3 (—) 0.66	27.1 (—) 0.37
19 - 24	30.2 (—) 0.76	30.6 (—) 0.95	27.8 (—) 0.36	26.0 (—) 0.43	29.5 (—) 1.37	29.7 (—) 1.16	32.5 (—) 0.96	29.6 (—) 0.62

proximately 5 months elapsed between the tillage and dynamite treatments of 1918 and the taking of the first regular set of samples on April 11, 1919.

The plots of Series 400 had been given the tillage and dynamite treatments in the fall of 1917 and had received but one such treatment. Tables 3, 4, and 5 contain the data obtained in this first season's work.

The probable error of the seasonal average (average of averages) is computed by means of the formula:

$$\text{P. E.} = (-)\ \frac{1}{N}\sqrt{n_1^2 e_1^2\ (-)\ n_2^2 e_2^2\ \cdots\ n_n^2 e_n^2}$$

In which N = total number of borings entering the average
n = number of borings in each average
e = probable error of average.

It will be noted that there is no significant difference in the moisture content of the differently treated plots of either series. The moisture content of Plots 2, 3, and 4 is higher in each case than that of the corresponding stratum in Plot 1. It seems apparent, however, that this fact must be attributed to soil heterogeneity rather than to treatment, for corresponding behavior is not found in Plots 14, 15, and 16 compared to Plot 13.

During the spring of 1920 this work was continued by taking four sets of samples from Plots 5, 6, 7, and 8. These plots had received the tillage treatment in the fall of 1915 and again in the fall of 1919. Fourteen systematically distributed borings per plot instead of five were taken during this season's work in order to increase the reliability of the average. The strata sampled were the same as in 1919. Table 6 contains the data obtained during this season's work.

It will be noted again that there are no significant differences in the moisture content of these plots in 1920 which had received a tillage treatment the previous fall and one in the fall of 1915.

It seems apparent that neither the subsoiling, deep tilling, or dynamiting have had any effect which is reflected in the moisture content of this poorly drained prairie soil.

Table 3. Average Percent of Moisture, 5 Borings Per Plot. 1919
Surface 0 - 7 Inches

Plot	1	2	3	4	13	14	15	16
April 11.....	21.5 (—) 1.55	24.9 (—) 1.56	24.3 (—) 0.59	25.5 (—) 0.90	27.4 (—) 0.09	29.3 (—) 0.33	27.1 (—) 0.65	27.5 (—) 0.86
April 25.....	18.8 (—) 1.40	22.0 (—) 1.54	20.8 (—) 0.48	21.2 (—) 0.83	21.2 (—) 0.52	23.6 (—) 0.52	20.5 (—) 1.00	21.6 (—) 0.62
May 19.....	23.8 (—) 0.78	25.3 (—) 0.94	25.6 (—) 0.71	26.8 (—) 0.83	26.6 (—) 0.25	27.2 (—) 0.92	25.6 (—) 0.38	27.2 (—) 0.56
May 29.....	25.3 (—) 0.39	26.3 (—) 0.68	26.1 (—) 0.41	27.0 (—) 0.66	27.2 (—) 0.22	27.1 (—) 0.20	26.0 (—) 0.46	26.3 (—) 0.37
June 2.....	20.1 (—) 0.38	20.9 (—) 0.58	20.3 (—) 0.99	21,8 (—) 0.96	24.5 (—) 0.22	25.6 (—) 0.29	23.7 (—) 0.80	25.1 (—) 0.61
June 19.....	17.4 (—) 0.56	18.0 (—) 0.58	18.4 (—) 0.44	18.1 (—) 0.65	22.4 (—) 0.26	23.7 (—) 0.16	22.4 (—) 0.85	23.9 (—) 0.35
Seasonal Av...	21.1 (—) 0.38	22.9 (—) 0.42	22.6 (—) 0.26	23.4 (—) 0.33	24.9 (—) 0.11	26.1 (—) 0.19	24.2 (—) 0.31	25.3 (—) 0.24

Table 4. Average Percent of Moisture, 5 Borings Per Plot. 1919
Subsurface—8 Inches to the Tight Clay

Plot	1	2	3	4	13	14	15	16
April 11.....	19.7 (—) 1.01	23.1 (—) 1.46	24.8 (—) 1.49	22.7 (—) 0.90	24.3 (—) 0.19	26.5 (—) 0.29	24.1 (—) 0.70	22.7 (—) 1.08
April 25.....	17.7 (—) 1.04	20.5 (—) 0.77	22.3 (—) 0.48	23.5 (—) 1.01	21.8 (—) 0.20	23.9 (—) 0.52	22.1 (—) 0.66	20.7 (—) 0.36
May 19.....	20.8 (—) 1.29	23.2 (—) 1.02	25.7 (—) 0.63	24.0 (—) 0.83	24.8 (—) 0.21	25.9 (—) 0.26	25.6 (—) 0.98	23.5 (—) 0.71
May 29.....	21.6 (—) 1.03	24.7 (—) 1.16	26.4 (—) 1.10	25.1 (—) 0.96	26.8 (—) 0.40	27.9 (—) 0.59	25.1 (—) 0.81	25.2 (—) 0.85
June 2.....	17.9 (—) 0.81	19.9 (—) 0.74	22.7 (—) 0.50	20.8 (—) 0.87	22.9 (—) 0.13	24.7 (—) 0.23	22.4 (—) 0.97	21.7 (—) 0.64
June 19.....	17.0 (—) 0.75	18.7 (—) 1.30	19.5 (—) 0.55	18.8 (—) 0.62	20.8 (—) 0.14	22.5 (—) 0.23	21.4 (—) 0.95	23.2 (—) 0.70
Seasonal Av...	19.1 (—) 0.41	21.7 (—) 0.45	23.6 (—) 0.35	22.5 (—) 0.35	23.6 (—) 0.09	25.2 (—) 0.15	23.6 (—) 0.35	22.8 (—) 0.31

Table 5. Average Percent of Moisture, 5 Borings Per Plot. 1919
Subsoil, 6 Inches of Tight Clay

Plot	1	2	3	4	13	14	15	16
April 11.....	27.5 (—) 1.01	28.2 (—) 0.89	29.6 (—) 1.34	29.1 (—) 0.36	30.3 (—) 0.55	31.4 (—) 1.06	29.9 (—) 0.73	27.9 (—) 0.38
April 25.....	26.4 (—) 1.05	28.5 (—) 0.77	28.3 (—) 1.14	26.2 (—) 1.00	26.8 (—) 1.00	29.4 (—) 1.14	28.7 (—) 0.46	28.3 (—) 0.56
May 19.....	25.2 (—) 0.85	29.1 (—) 0.55	29.9 (—) 1.09	28.6 (—) 0.56	29.8 (—) 1.10	30.7 (—) 0.91	29.7 (—) 0.49	28.2 (—) 0.77
May 29.....	26.0 (—) 0.77	29.1 (—) 0.58	30.1 (—) 0.79	28.4 (—) 0.61	29.9 (—) 0.84	31.3 (—) 0.84	29.4 (—) 0.61	29.5 (—) 0.62
June 2.....	25.9 (—) 1.20	28.9 (—) 1.08	29.4 (—) 0.70	27.8 (—) 0.64	25.8 (—) 0.85	29.2 (—) 0.74	28.6 (—) 0.82	27.8 (—) 0.72
June 19.....	26.7 (—) 0.99	27.5 (—) 1.52	28.6 (—) 0.58	28.4 (—) 0.56	26.9 (—) 1.38	29.8 (—) 0.87	25.1 (—) 1.32	26.8 (—) 1.72
Seasonal Av...	26.3 (—) 0.40	28.5 (—) 0.39	29.3 (—) 0.40	28.1 (—) 0.27	28.2 (—) 0.40	30.3 (—) 0.38	28.6 (—) 0.32	28.1 (—) 0.37

Table 6. Percent of Moisture, 14 Borings Per Plot. 1920

Plot	5	6	7	8
Surface 0 - 8 Inches.				
April 30	29.4 (—) 0.33	29.3 (—) 0.24	27.2 (—) 0.16	29.4 (—) 0.27
May 7	27.5 (—) 0.35	27.8 (—) 0.25	25.8 (—) 0.22	29.8 (—) 0.18
May 15	28.2 (—) 0.50	28.2 (—) 0.25	25.1 (—) 0.25	29.2 (—) 0.21
May 21	28.9 (—) 0.28	28.3 (—) 0.27	26.1 (—) 0.20	28.4 (—) 0.28
Seasonal Av.	28.5 (—) 0.19	28.4 (—) 0.12	26.1 (—) 0.10	29.3 (—) 0.12
Subsurface 8 Inches to the Tight Clay				
April 30	25.0 (—) 0.44	22.9 (—) 0.34	23.8 (—) 0.16	24.2 (—) 0.26
May 7	23.3 (—) 0.40	22.0 (—) 0.32	22.9 (—) 0.20	24.6 (—) 0.23
May 15	24.1 (—) 0.46	24.1 (—) 0.30	23.7 (—) 0.18	25.1 (—) 0.29
May 21	26.3 (—) 0.34	25.7 (—) 0.41	25.5 (—) 0.27	25.9 (—) 0.18
Seasonal Av.	24.9 (—) 0.20	23.9 (—) 0.17	24.0 (—) 0.10	24.9 (—) 0.12
Subsoil 6 Inches of Tight Clay.				
April 30	28.1 (—) 0.43	25.6 (—) 0.44	25.8 (—) 0.31	26.1 (—) 0.21
May 7	27.5 (—) 0.37	25.4 (—) 0.52	25.3 (—) 0.27	26.9 (—) 0.01
May 15	27.3 (—) 0.51	27.3 (—) 0.35	25.2 (—) 0.28	26.3 (—) 0.22
May 21	28.9 (—) 0.18	26.3 (—) 0.19	26.0 (—) 0.32	26.1 (—) 0.26
Seasonal Av.	27.9 (—) 0.20	26.1 (—) 0.21	25.6 (—) 0.14	26.3 (—) 0.10

Crop yield has also been taken as a criterion of effect and here also no consistent or significant difference in the yield of the various plots has occurred.

This information, while entirely negative, is of considerable value as a guide in planning future work which may lead to the discovery of a method of underdraining this extensive area. It also furnishes the Experiment Station with a sound basis upon which to base advice to farmers of this region regarding the advisability of purchasing subsoil or deep tillage plows, or of using dynamite in an effort to shatter and render more pervious the tight clay subsoil. These investigations, together with similar investigations which have been carried on at other stations, seem to point without question to the conclusion that the remedy for this unfavorable subsoil condition is not to be found in deep tillage or in the use of dynamite. Further investigation must determine whether a practicable remedy can be found. The problem is of such far-reaching economic significance that upon its successful solution depends, to a large extent, the material welfare of an extensive area in Illinois.

The possibilities of attack have not been exhausted and valuable information has been secured in the work thus far attempted. Future efforts, it seems, must first be directed toward a study of the exact nature and behavior of this plastic material, and then with this knowledge as a basis we will be in a position to attack the problem in the field more intelligently.

Discussion of Paper on "The Agricultural Significance of the Tight Clay Subsoil."

Mr. Haas asked whether the failure to have any effect through deep plowing, subsoiling or dynamiting might not be due to lack of underdrainage or tiling. In his own experience on a small scale in northern Ohio through dynamiting, from appearances, only, there seem to be a distinct gain in "drawing" power of tile as well as the growth of plants. In reply to the question whether the negative results obtained might not be due to the plowing down of the soil rich in humus and bringing to the surface of large quantities of gumbo, Mr. Smith replied that the color of

the surface soil on the plots plowed with the deep tillage machine was distinctly changed, showing a mixing of the subsurface and subsoil with the surface, but that no such inversion has taken place on the subsoiled or dynamited plots, and that no effect on the drainage could be discerned on any of the plots.

THE PLANT ECOLOGY OF THE ROCK RIVER WOODLANDS OF OGLE COUNTY, ILLINOIS

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INTRODUCTION

Ogle County is located in the northern part of Illinois in the second tier of counties just west of the center line of the state. It is an irregular parallelogram in outline, some 39 miles in its widest west-east and 29 in its north-south direction. The total area is about 750 square miles. The area dealt with specifically in this paper comprises some 75 to 80 square miles along the Rock River, with a small area to the west of the Rock on Pine Creek.

The larger part of the surface of the county is overlaid by glacial drift, generally so thinly as rarely to attain even 20 feet depth, and reaching its maximum of about 125 feet only in the northwestern part. The elevations above sea level run from about 700 to 900 feet. The Rock River, a moderate sized stream, takes a general north-east to south-west course through the middle of the county, with three or four main tributary streams entering it from the west and the east. It makes a great bend near the southern border of the county. The course of the Rock takes it through Iowan drift, which overlays more than half the county and affords good drainage without swamps. From the southern boundary an irregular area, varying from a few hundred feet to 10 or 12 miles wide, underlain by St. Peter's sandstone, extends northward along the Rock on either side for about two-thirds of the distance to the northern boundary. The remainder of the county, with the exception of a small area of the sand-stone at the west boundary and some shales at the south-east corner, is underlain by Trenton-Galena limestones. Outcrops of both sandstone and limestone in cliffs and walls occur along streams.

The larger part of the county is undulating prairie. Here occur groves of upland prairie oaks. Along the river and creeks the country is more or less hilly. Here there is a fair growth of woodlands.

ROCK RIVER

The Rock River, rising in southeastern Wisconsin, has a course of some 300 miles, flowing southwestward to empty into the Mississippi River below Rock Island, Illinois. It has a drainage area of about 11,000 square miles, half of which is in Wisconsin in the Wisconsin glacial drift, affording poor drainage with the occurrence of many swamps, and half in Illinois in the Iowan glacial drift, affording good drainage with no swamps.

The course of this river has been greatly altered since the Pleistocene ice age. Its former valley is much to the east of the present one in Ogle County. The preglacial valley is departed from in Winnebago County before reaching Ogle County, but in Ogle the river takes its way along the valleys of certain of the preglacial tributaries and in large part along a postglacial course. Thus the Rock follows the preglacial valley of the Leaf River for a few miles in the vicinity of Byron in the north of the county but in the reverse direction from that of the preglacial Leaf, and uses as well some of the small preglacial tributaries. Farther south Kyte River flows northwestward into the Rock below the town of Oregon in the valley of a preglacial western tributary of the Rock. The head of this is in the hills back of the town of Oregon, the present Rock cutting off only the headwaters portion of the preglacial valley. Several smaller streams also had preglacial courses cutting across the present Rock River which now intersects several of them midway of their course and diverts them westward into the Mississippi River by way of the Rock. From not far south of the Kyte the Rock appears to follow the line of a small preglacial stream as far as the mouth of Pine Creek, in a valley varying from about one quarter of a mile to as much as a mile in width at Grand Detour where the river makes its big bend. The course of the Rock, then, from where it turns away from its broad preglacial valley in southern Winnebago County, is in Ogle County southwestward through a much narrower valley, a valley that is postglacial except where the Rock occupies the valleys of preglacial streams. In this postglacial course the river is about 500 feet wide in a valley varying from 1000 feet

to 1 mile in width. Its total fall in Ogle County is only some 50 to 60 feet. It is this narrow portion that has given rise to the river bluffs.

At Byron there are deposits of glacial gravel some 50 feet above the low water level of the Rock. At Oregon such deposits also occur, being some 40 feet here, and they extend thence to the southern end of the county and beyond. Remarkably small excavation by the river has taken place since the deposition of this gravel. The rock excavation has been interglacial and the gravel excavation postglacial, the period of the rock excavation having been the longer and for the greater part in limestone. Today the outcrops seen along the Rock in Ogle County are mainly St. Peter's sandstone, which outcrops for some 14 miles in banks from 25 to 200 feet in height. It is this that forms the bluffs for some two and a half miles above the town of Oregon, near the middle of the county, to below Grand Detour at the southern end. In color this sandstone is from nearly white to golden yellow and dark brown, from the iron once held in solution by the water. Sometimes these bluffs are capped by limestone, as on the east side of the Rock north of Oregon where the Black Hawk statue stands. Liberty Hill, west of Oregon, is also of this sandstone capped by limestone. A few miles north of Oregon, and south of the mouth of Pine Creek near the southern boundary, the outcrops rapidly decline. In the St. Peter's sandstone there are sometimes ferruginous layers which, being more resistant to erosion, are often left as brown to almost black parallel or circular ridges. This is well shown at Hotel Rock, on the west shore about four miles south of Oregon. Again the sandstone may occur as an almost white, non-ferruginous variety, consisting of almost pure silica, as at Castle Rock on the west shore just north of Hotel Rock, where the stone is soft, friable, and very porous. In the ravines about the town of Oregon buff limestone occurs, and it is this that caps the sandstone of the river bluffs upon which the statue of Black Hawk stands opposite Oregon. Certain creeks emptying into the Rock show St. Peter's sandstone at their mouths, then, farther up stream, the buff limestone, and still farther up blue limestone, and finally Galena

limestone as a rock wall, this last being dull gray to cream color, coarse-grained and porous. It is the Galena limestone that forms the bluff at Pine Creek upon which grows a stand of white pine. The above limestones, belonging to the Trenton group, are sometimes referred to as the Trenton-Galena limestones.

The Rock, on the whole, may be considered as, even in the preglacial beds, an immature postglacial river, since some erosion has taken place since the glacial period. Considered thus it is in the second phase of river development, that of bluffs, with erosional and depositional banks at various places. In this mid-phase of river development there frequently occurs an overlapping of bluff and flood-plain, and this is seen in the Rock. It should be noted, too, that much of the flood-plain development is artificial in nature, due to the formation of sand and gravel bars after the breakage of dams, as at Oregon and Grand Detour.

It will be seen that the region is one altogether of the varied physiography of a river in its mid-phases with an accentuation of the topography in many places owing to the older preglacial parts. The soils belong to the following classes of the five recognized by the State Soil Survey. Upland timber soils, the yellow to yellow-gray loams. Residual soils, including stony loam and rock outcrop. Terrace soils, which include bench lands (second bottom lands, formed by deposition from overloaded streams during the melting of the glaciers). Bottomland soils, which include the overflow lands or present flood plains along streams, and other poorly drained lands. The last class includes swamp soils elsewhere in the state. There are, however, no swamps in Ogle County. The remaining soil class, outside of the region especially under consideration in this paper, is that of the upland prairie soils, in the main the brown loams. These are rich in organic matter and are said to have been covered originally with prairie grasses, whose partly decayed roots have been the source of the humus. The upland timber soils are said to include practically all of the upland that was formerly covered with forests. The question raised thus, as to whether the vegetation caused these soils to be-

come what they are or whether the soils caused the representative vegetative assemblages, is outside the province of this paper.

The alternation of loam and clay found in Ogle County is a thing common to glacial regions. Some limestone residual soil occurs and there are residual sandy areas arising from the disintegration of sandstone. The most marked contrast and the most notable soil difference for vegetation, whatever may be the part the vegetative assemblages play in this, is that between the rich brown or black loam of the gently rolling prairie back from the Rock River and its tributaries and the more rapidly eroding clays, much poorer in humus, nearer the streams.

NATIVE VEGETATION IN THE PAST

In the geological past, since the last retreat of the Pleistocene ice, it seems certain that there was a time when the vegetation of the county comprised in large part white pine (Pinus strobus) as its chief tree growth. As the climatic change following the retreat of the ice took place through thousands of years, coniferous species became more and more replaced by the tree species that occur as the chief ones today, in response to the conditions furnished by the present climatic cycle. White pine is able to persist still, however, as a relic of the former vegetation. Careful searching of the old records as contained in the county histories of northern Illinois and of Wisconsin, and of old maps as well, indicates that for the geologically brief instant during which white men have been in the region this white pine has existed only in the form of isolated areas and not as extended arms of growth from the north which have since become cut off into these scattered parcels. This evidence, though not conclusive, greatly increases the probability. Since the first coming of the whites about the middle of the nineteenth century even these stands have been mostly wiped out or persist only in the form of a few trees.

Previous to about 1840 the inhabitants of Ogle County were chiefly Indians. A few French occasionally came to the region that is now the county after La Salle came to Illinois late in the seventeenth century. It has been estimated that

possibly five thousand Indians went up and down the Rock River valley and had a few small villages along it. Hunting and fishing, not agriculture, were the occupations, and consequently these early people were roving instead of settled in certain locations. This has had its influence on the vegetation, both in the way of less disturbance to it than would result from a settled agricultural population and in the way of the relation of the Indians to prairie fires. These were purposely set for various reasons and have unquestionably had an enormous influence on the native vegetation. The exact extent of this influence may never be definitely known, but the early records of the whites agree in furnishing direct and indirect evidence of great weight as to the colossal effect. Early records of Ogle County, besides prairie fires of smaller size, mention two that occurred in successive years and ran from the Mississippi River eastward to the Rock River.

When the whites began settlement about 1840 woodlands extended along the Rock on either side for varying distances and along its tributary streams. According to the earliest accounts the prairie ran down to the water's edge in only a few places. Elsewhere were the so-called "groves," patches of woodland of varying size usually along water courses and in the neighborhood of springs. These woodlands must not be understood as mere narrow belts along the creeks; frequently they occupied considerable areas. By far the larger part of the county was undulating prairie land. Perhaps 15-20 per cent may be said to have been woods. It is interesting to note that the early accounts of these "groves" mention oaks, walnuts, elms, maples, hickory. This is a rather different community from the prairie grove of the present time. The same early accounts speak of the woodlands along the Rock and its tributaries as containing oaks, walnut and butternut, hard maple, elm, hickory. Here the assemblage is characteristic today. An account of the woods west of the Rock, in Mount Morris township, written about the middle of the nineteenth century, mentions them as scrub timber growth in what was largely an open country. The reason for the scrubby form is given as prairie fires.

As well as may be ascertained today the original areas of woodland, about 1840 and for an indefinite period before then, were approximately as represented on the map issued by the County Superintendent of Schools about 1900. The singular fact that these wooded areas should remain about the same in extent for over half a century is said to be explained as follows. During the years 1840 to 1900 the nature of the woods underwent great change at the hands of the whites. During this time a haphazard selection cutting rather than actual clearing is what prevailed, desirable species of trees of large size being cut out promiscuously. From about 1880 to 1900 actual clear cutting was more notably under way, but this was of such a degree that it did not become strikingly noticeable until about 1900. From this date onward, however, the clearing became great until very recent years, along with further selection cutting, the latter still going on. Today Ogle County has over 30,000 inhabitants. About 5% of the land in the neighborhood of the Rock may be estimated as wooded. A recent estimation for the northwestern part of Illinois of 8% may serve for rough comparison.

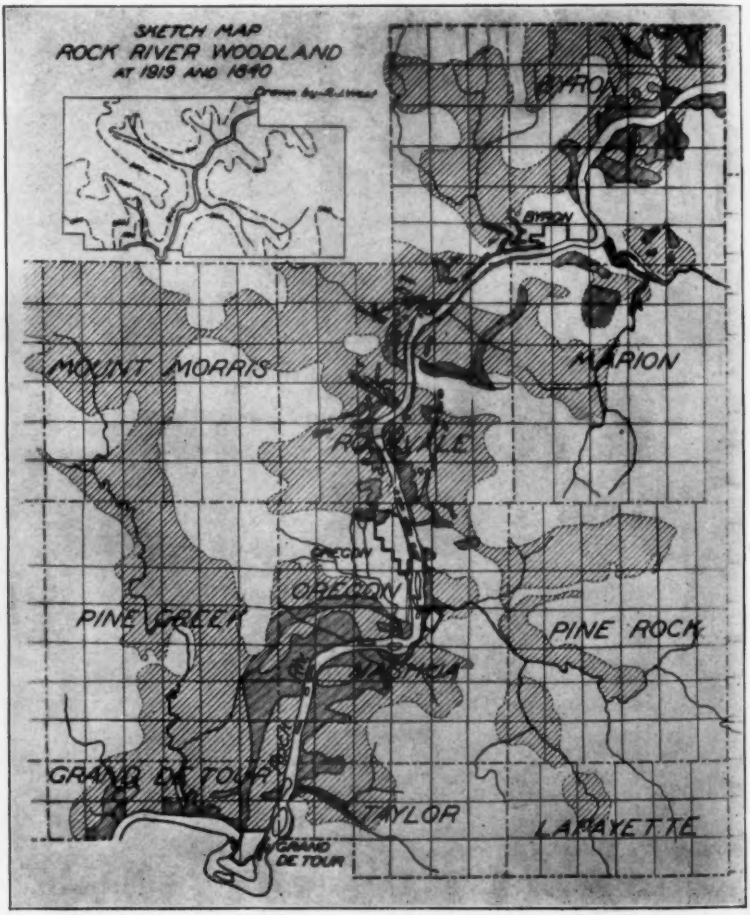
THE VEGETATION

The Rock would probably be referred to as a prairie river located in the grasslands (prairie)—deciduous forest transition area of North America. This transition belt, as is well known, possesses characteristics, in the species of plants present, of the deciduous forest area to the eastward and of the grasslands to the westward. The prairie areas of this transition belt comprise the major part. Its affinity with the east is expressed in the woodlands along streams and extending out irregularly from these. Although Ogle County lies in this transition a more exact delimitation of ecological boundaries takes note of what is known to plant geographers as the prairie peninsula. This is an arm of grassland extending eastward into Illinois and adjacent states. It grazes Ogle County at the south.

Further, while the above statement holds good in a general way, the Rock River woodlands are not thoroughly typical of the prairie river. In some respects they are more representative of the eastern portion of the transition belt.

Thus the wooded area on either side of the Rock, in its original extent, was about equal. See the sketch map on page 160. In the typical prairie river wooded region the greater extent of the woods is on the west of the river. The potential mesophytism, if not the actual mesophytism, is greater in degree and in extent in the Rock River woodlands region than in that of any true prairie river. An examination of the Rock in Ogle County shows that the intrenched valley must expose here on either sloping side a set of soils that is different from the prairie soil. This is typical of the middle and lower courses of the prairie rivers. In general, too, the east side of the valley is wider than the west side, and the east is also generally of somewhat lower slope. This, again, is typical of the prairie river. On the Rock River this is locally greatly broken into an account of both the preglacial character of much of its course in Ogle and the physiographic diversity of the postglacial portion, so that the statements hold true only for the general aspect of the entire course in the county.

In part this transition belt is a savanna. This term is often used in order to compare it with other similar areas of the world that go by this general name. Many parts of this North American transition unquestionably furnish examples of true savanna, chiefly of the patchy type, where, in a grassland, patches of tree growth frequently occur. This is almost the same thing as the "oak openings" often mentioned in literature descriptive of the early days of settlement, with the possibility that the oak openings comprised rather more frequent wooded portions than characteristic patchy savanna. In some places the park-like savanna occurred. Here the grassland was set not with patches of tree growth but with isolated trees far enough apart to make it possible to drive about through the area. The early records of Ogle County make reference to such a form in Mount Morris township and the reference makes it highly probable that this example arose as the result of prairie fires. Other examples must have existed and there is likelihood that prairie fires were an important if not decisive element in their creation.



ROCK RIVER WOODLANDS

Showing their original extent, based on the map issued by the County Superintendent of Schools in 1900, and on field sketches by the writer in 1919.

The Rock River Woodlands are the vegetation response of this particular part of the world to the conditions of inland plant succession in the depressions of the erosion topography of a river system that may be considered, in general at least, as in its mid-phase of ravines, bluffs, and flood plains. A varied assortment of habitats for plant life is a corollary. Early xerophytic ravine stages through to extremely mesophytic late ones in both clay and loams are present, with the rock bluff phase of river action in sandstone and limestone, the depositional phase of flood plains, and depositing and eroding shores. This is the structure that has already been described as the Rock River system in Ogle County, with its vegetational history as already briefly outlined. Further, into all this there has been projected an element of powerful effect in the changes wrought by it directly and indirectly on the topography and the vegetation. This element is that of the various activities of men. It is in its effects from minor to cataclysmic and from slow to the swiftest of all factors.

FACTORS OF THE COMPLEX

In the chains of causation leading to certain effects it is customary today to stress particularly the physical and chemical alterations in the surroundings, that is to say in the kinds and the rates of processes making up the conditions under which things exist and change. From the scientific standpoint this is, of course, desirable since it is always the more fundamental that is needed for establishing principles of application that approach universality. Today, however, the whole story, so to speak, of many occurrences in nature cannot be expressed in physical and chemical terms. The development of vegetation, for example, cannot possibly be told in such terms alone, whatever may be possible at some later time. An account of the plant ecology of any locality must necessarily use other means of expression also. So, for a qualitative investigation of vegetation, an artificial classification of the "factors" or elements of the different complexes involved is desirable. A common, very general one, of great use in the past but now somewhat outworn, is the division into topographic and biotic factors. Another recognition of this is to be seen in the still very use-

ful though purely artificial separation into 1) Primary Succession; that resulting from natural causes, and 2) Secondary Succession; that resulting from disturbance by man. This is wholly a classification of convenience. The different categories may, in many cases, overlap considerably in so far as the laws of physics and of chemistry are concerned. But this is of no great importance in a qualitative investigation. Nor need it interfere at all with quantative investigation of vegetation, where an endeavor is made to seek out physical and chemical relations in plant life or to advance our present defective state of knowledge concerning quantitative methods of investigating such phenomena.

A simple classification of convenience for the purposes of the qualitative investigation in hand is as follows:

Activities of men,
Climatic fluctuations,
Fires,
Plant diseases,
Principles of plant succession.

The first of these categories may obviously be split up into such heads as:

Clearing,
Cutting,
Grazing,
Burning,
Weed introduction,
Crop raising,
Industrial developments,
Artificial planting.

Since no complete handling of all these elements is at all possible it will be well to dispose here of a few that are either of lesser importance or are practically impenetrable, reserving the more important or more feasible for a later discussion, after the plant ecology had undergone consideration.

The height of water in the Rock River and its volume of flow is influenced not only by natural causes but by industrial development. The water is artificially ponded often behind the dam at Rockford in Winnebago County to the north

of Ogle, causing abnormally low water. This is followed by the sudden release of the water, and, consequently, unusual influences of stream flow are at work at times upon the shore lines of islands and mainland. Island formation has been greatly influenced in places by the building of bridges, as at Oregon, and the breaking of dams, as at Oregon and at Grand Detour. Artificial islands have been created by the gravel and detritus washed from a broken dam against the piers of a bridge, as about the iron bridge at Oregon. The effect of ice, when ice gorges break farther north in the river in February or March and send down the river great quantities of ice, has been marked on shore lines and on island erosion and movement. There has beeen great change in the river islands in the county within the last few decades. The map issued about 1900 by the County Superintendent of Schools exhibits a number of differences from the recent, still unpublished, map of the State Soil Survey, and it is possible today to trace the course of some of these changes. The earlier map shows a rather large island immediately north of Margaret Fuller's island above Oregon. No island exists there now, but a very small one farther up stream near the west shore shows evidence of being the remains of the former larger one, since southward from it the remains of stems of dead willows may be seen sticking above the surface at low water. In a number of other locations similar effects may be seen. The arrangement of the islands south of the iron bridge at Oregon is strikingly different now from that of the earlier map, and the reasons for this are known in the events of the past fifty years or so. The dynamism of the islands is probably still of a high rate at times so far as their disappearance and appearance is concerned, while that of their progression downstream is generally that usually encountered in a stream of this character. The canalization near the mouth of Pine Creek near the southern boundary of the county, whereby the lower end of the creek was afforded a shorter course, also presents an artificial rearrangement of natural conditions. It should be noted that much of the industrial development on the Rock assists natural causes in making the river a depositing as well as an eroding stream. The muddiness of

the water, due to the load carried, is frequently commented upon, whereas before the advent of the whites its clearness was equally noticed.

The artificial planting that has been done in the county is mainly of an ornamental nature and there is no evidence as yet of the further establishment of these introduced species by natural means. As a factor this is still negligible. Unintentional weed introduction and the natural migration and establishment of weed species of plants has, probably, been very great since the settlement period about the middle of the nineteenth century. One need refer to the case of the giant ragweed (Ambrosia trifida) alone for an indication of how widespread this influence may be upon the native vegetation. This species, locally known as "horseweed," is having a marked ill effect economically in its invasion of farm areas. The entire matter of weed introduction is a practically unknown factor, however. The effect of crop raising on the native vegetation is, like its reciprocal, the effect of native vegetation on crop areas and the raising of different farm crops, practically an unknown territory. One aspect of this that seems likely to come up before many years for careful investigation by ecological methods is the effect of grazing by domestic stock on the permanency and the yield of farm pasturage. The ecological method of regulating grazing on western ranges has already been successfully worked out and applied. The effects of grazing animals on the Rock River woodlands will be considered here, however, after the plant ecology of the areas has been dealt with. It needs merely to be mentioned now as one of the prime factors of the region in the ecology of the native vegetation. Plant diseases among the native species is a wholly unknown factor so far as the past is concerned. References occur, to be sure, in various records of county affairs, but these references are all so general in nature as to be of little value, consisting mainly of such statements as that after the severe winters of a certain period there was much disease among the native trees. It will probably remain one of the unknown factors of the past.

There remain, then, for later discussion the topics of clearing woodlands, cutting out various species of trees

from them, fires in such areas, grazing within them, with such consideration of the principles of plant succession as appear pertinent, and the matter of possible climatic fluctuation. It may be well to emphasize that what is desired even in a qualitative investigation of these factors is some knowledge of the attendant alterations in such things, for example, as soil moisture content, physical character of the substratum, effects on the plant assemblages, as well as more general information and certain outstanding principles or isolated facts.

THE PLANT ECOLOGY

Just what the Rock River woodlands contained in plants besides tree species before white settlements got under way is somewhat speculative. The most striking thing about the early accounts appears to be the great similarity between the species of trees then present in the woods along the Rock and in the woods well back from the river, that is in many of the prairie groves. Mention of "large oaks" is frequent, and sometimes a diameter of three or four feet is given for them as well as for elms. Large walnut and butternut are also spoken of and the hard or sugar maple. The writer believes that there was more mesophytism than now, that if not a very much higher degree of it, it was at least greater in areal extent.

It is believed, too, that the climax form today of the Rock River woodland region is one of very considerable mesophytism. The highest expression of this is to be seen only in spots of woodland, while certain larger areas exhibit it also but expressed in lower terms. It must be remembered that the region presents other woodland associations of high mesophytism besides this climax form. These are the bottomland association and the streamside association, almost identical in floral composition, the former of which is notable on the islands while the latter is common on the banks of the Rock and other streams of continuous flow. Here the ruling species of trees are Acer saccharinum, Ulmus americana, U. pubescens, Salix nigra, S. fluviatilis, Acer negundo, Fraxinus americana. When ungrazed, Ambrosia trifida and Urtica dioica are characteristic also. The climax form when at its highest expression contains such trees

as Acer saccharum, A. nigrum, Tilia americana, Prunus serotina, Hicoria minima, Juglans cinerea, J. nigra, Fraxinus americana, Quercus alba, Q. rubra. The following shrubs are rather typical of the undergrowth—Viburnum dentatum, V. lentago, Staphylea trifoliata, Hamamelis virginiana, and, sparingly, both Amelanchier canadensis and Carpinus carolianiana. Some characteristic herbs and ferns are Viola spp., Podophyllum peltatum, Trillium spp., Sanguinaria canadensis, Asarum canadense, Hepatica spp., Aralia nudicaulis, A. racemosa, Actea rubra, A. alba, with Menispermum canadense and Amphicarpa monoica among the lianes; Adiantum pedatum, Osmundas, Aspleniums, Aspidiums. The oaks are still the dominant trees generally both in point of numbers and of size. The maple element sometimes is represented by trees of good size but they are generally still subordinate in point of numbers. In a sense this is a beginning aspect of a climax form, as an inspection of the list of species named will indicate. The writer believes there is considerable evidence on the ground that goes to show that this form may not be the ultimate expression, under the prevailing climatic complex, but that a still more mesophytic expression may be the real climax form, if the successional development of the vegetation were allowed to take place without interference. It is speculation, of course, to indicate what the ultimate form might be. Since Fagus americana and Tsuga canadensis are absent, even as possible migrants, the beech-maple-hemlock climax of farther east is out of the question. It is conceivable, however, and rather probable, that an ultimate association might involve the well-nigh complete elimination of Quercus alba and perhaps of the more mesophytic Quercus rubra, resulting in a maple association. In much of the eastern portion of the middle west of North America a red oak-white oak-hickory association (Quercus rubra-Quercus alba-Hicoria ovata) is the climax. Sometimes the course of the succession to this is likened to that of the country farther east with the exception of the elimination of the eastern climax of beech-maple-hemlock. The association considered here as the climax of the Rock River woodlands region may be termed an oak-maple climax. It is not believed that this is, or would be if left to its natural

development, peculiar only to the Rock River region but that it would gradually spread over more or less of the county outside of that specifically dealt with in this paper. This oak-maple climax is to be seen well in portions of the Cartwright woods on the west side of the Rock north of Oregon and in the east shore part of the McCormack woods north of Byron. The association has become in large part independent of physiographic diversity, that is to say, it is found not only in small ravine heads for example, which afford especially favorable mesophytic conditions, but spread over larger physiographic areas that involve much diversity of habitat. The floral composition of the association in such examples of the climax will be treated in more detail later. From the viewpoint of geological time, of course, the mesophytism of the Rock River woodlands region is a temporary effect. Geologically later, when lateral erosion of the river has approached planation, mesophytism will have disappeared.

For contrast, in order to get an impression of the course of the plant succession, and some idea of the probable effectiveness of the factors influencing it, let us consider an association representing the other extreme, a xerophytic woodland. Although not especially concerned with the prairie groves as they remain in the county today, chiefly in the form of degenerate farm woodlots, they will, nevertheless, serve the purpose. Their mesophytism when white settlers first came into the county about 1840 has already been noticed. While not applicable to all prairie groves eighty years ago many of them certainly comprised an assemblage of plants whose mesophytism is indicated by the presence of such species as maples, walnuts and elms, besides the oaks. Today, after less than a century of occupation by the whites, these groves or woodlots generally contain an association whose retrogression is indicated by their composition of oaks and hickory. The typical species are Quercus macrocarpa, Q. ellipsoidalis, Q. velutina, Q. alba, Hicoria ovata. Since the variations comprise almost all possible combinations of these species no more definite statement is necessary. In this connection there must be compared what has happened when the course of the plant

succession was in the reverse direction. The prairie groves have exhibited a movement of plant succession towards xerophytism from a rather high form of mesophytism, as retrogression due to the activities of man. Near Lincoln, Nebraska, an area of prairie, bearing the usual sod grasses, was made, by the activities of man, to exhibit a movement of the plant succession towards mesophytism from some degree of xerophytism. Some forty years ago seedling trees were planted in the prairie sod grass. Now the sodded condition has disappeared and the area has shown progression into a rather mesophytic woodland.

Among the species given as representative of the prairie groves, or their remains, the farm woodlots of today, Quercus macrocarpa is a typical border line tree between prairie and woodland. It is also, however, a species of very different habitat, occurring in places of great soil moisture, as for example, on the Leaf River flats. It is to be found, too, in other habitats of soil moisture conditions apparently intermediate between these, where it may be a left-over from another set of conditions. It is quite possible that a statistical investigation would show it to be more plentiful in that portion of the area being dealt with that is west of the Rock River.

Having now given some attention to what may be thought of as the two extremes of woodland growth, the prairie grove or farm woodlot association of today, just outside of the Rock River woodland region and the climax form of woodland within that region, some consideration of the intermediate stages and deviations from the customary forms of these are in order. As might be expected the physiographic diversity afforded by an intrenched river valley in the way of differentiation of habitat conditions along the line of mesophytism, that is increased soil moisture and decreased evaporation, has given rise to practically all variations between the two extremes. The typical prairie grove or farm woodlot association can be found today within the Rock region as well as upon the prairie. From the oak-hickory association of xerophytic tendencies the relative frequency of the more mesophytic oaks, Quercus alba and Quercus rubra, increases as the succession goes in the meso-

phytic direction. The latter of these two species is a mark of attained mesophytism generally, while the former, though indicating an increase in mesophytism usually, nevertheless occurs in so wide a range of conditions as to be a member of many stages, or degrees of stages, of the succession. All the phases, until a low beginning form of the climax itself is reached, appear to be variations on the oak representation. The occurrence of such species as Fraxinus americana and Juglans, while representative of advanced soil moisture, are probably less representative of a definite stage of succession, though generally present in the climax.

A deviation from the regularity of the succession is shown by the association at the foot of a limestone ridge capped by sandstone on the east shore of the Rock just above Oregon, and consequently with a western exposure. The representative tree species here are Quercus alba, Q. ellipsoidalis, Hicoria ovata, Juniperus virginiana, and infrequent specimens of Quercus macrocarpa. Since the ground cover includes such herbaceous forms as Monarda stricta, Melilotus alba, Rudbeckia hirta, Desmodium illinoense, Cassia chamaecrista, the assemblage may be taken to represent a response to xerophytic conditions on a rather dry western exposure. It appears to be evident from the surrounding growth that the xerophytism hereabouts has been and is still decreasing in areal extent. It is to be noted that for a number of years past the vegetation conditions have not been interfered with materially.

A frequent response to the changed conditions afforded by a stream that contains water at least the greater portion of the time is shown by the appearance of Juglans nigra and sometimes Gleditsia triancanthos in a stand of Quercus ellipsoidalis, Q. velutina, Hicoria ovata, Quercus alba. An herb such as Podophyllum peltatum is frequent. Migrants like Acer saccharum, Hicoria minima, Celtis occidentalis, indicate the direction in which the succession is going. A good example of this is to be seen in a woodlot east of the Rock opposite Oregon. Throughout the Rock River region Hicoria minima is an excellent indicator of good soil moisture. Celtis occidentalis, on the other hand, while often occurring correspondingly, as a seeming indicator of

still greater soil moisture, is to be found as well on sites that are so much drier as to make the species unreliable as an indicator.

In Oregon township, section two, there is a stand representative of mesophytism and xerophytism condensed. Here Quercus alba, Q. macrocarpa, Hicoria ovata, Quercus rubra, Hicoris minima, Tilia americana, Ulmus pubescens, Prunus serotina, P. virginiana, and Juniperus virginiana are intermingled. It is of course, a response to the physiographic arrangement, large differences taking place in small distances.

Two of the more unusual species of oaks, out of a total of seven noted by the writer in the region of the Rock River woodlands, are Quercus acuminata and Q. platanoides. The latter is seen chiefly on some of the islands, while the former has two different forms and occurrences. It is found in a mesophytic stand, as upon the west shore of the Rock north of Oregon at the place known as the Narrows, at the foot of a wooded talus and on the inner part of the adjacent flood plain. Here Q. acuminata has the form of very thin, chestnut-shaped, acutely lobed leaves, and is a tall straight tree. It is to be found also on limestone ridges, which may be furnishing rather dry or rather moist habitats. Here the species is a short tree, or at least not tall and straight, with very much smaller leaves that are considerably thicker and inclined to be lighter in color on the under surfaces, while nevertheless preserving the acutely lobed and chestnut shaped outline. These two types are so distinct in appearance as to seem different species. In the location at the Narrows Quercus acuminata occurs with Acer saccharum, A. saccharinum, Robinia pseudacacia, Juglans cinerea, Salix fluviatilis, and Populus deltoides, as the tree species, and Alnus incana and Cornus paniculata as characteristic shrubs. Mesophytic herbs constitute the ground cover. Consequently there is a telescoping or condensation, a combination of the typical streamside association with the woodland oak-maple climax, with Quercus acuminata as the ecological equivalent here of Quercus rubra. Alnus incana is, of course, common along streams, though the genus is not especially frequent in Ogle

County. Cornus paniculata occurs in such a variety of situations as to be almost a ubiquitous woodland species.

One of the most interesting displays of oaks is to be found just west of Grand Detour on the eroded anticline of the structural deformation crossing the Rock at that place and forming the rock bluffs on the north shore of the river in its western course beyond Grand Detour. The assemblages include Quercus velutina, Q. ellipsoidalis in its type form and its three varieties of intermedia, depressa, and coronaria, Q. alba, Q. rubra, and Q. macrocarpa, the last species being nearby at least. These woods exhibit, in their part on the tops of the sandstone bluffs, but not in the portion farther back from the river, the substitution of an oak stage in the succession for a coniferous stage. The recession of conifers in this county is to be explained not alone by the fact of their becoming relics of a past climatic circle but also by the fact of man's operations of cutting and clearing. Probably if Pinus strobus had chanced to be present in the neighborhood of these sandstone bluffs in sufficient numbers to effect migration and establishment, a white pine stage would have occurred in the succession before the oaks, as is customary in this section of the country, where the series pines-black oaks-white oak-red oak, (hickory)—up to the climax, skeletonizes the succession in part. Here, however, the white pine was not present in sufficient numbers to establish itself in new territory. That it is still able to do so, when present in sufficient numbers to form a nucleus for migration, is demonstrated in the notable instance of the white pine woods on the limestone bluff of Pine Creek in Pine Creek township.

At the sandstone bluffs west of Grand Detour a dry, sandy bank rises from shortly beyond the river side and continues as a sandy site on top of the bluffs. Wherever the vegetation has been able to advance considerably the sandiness has become modified by the accumulation of humus. The streamside species, Salix fluviatilis, S. nigra, and Acer negundo, are frequent along the river. The lower bank contains such species also. The moisture conditions below the surface are there hydro-mesophytic. Fraxinus

and Ulmus are added on this lower bank. Somewhat farther up the bank Ostrya virginiana, Juniperus virginiana, Celtic occidentalis, Gleditsia triacanthos, are present. Still farther up are the oak woods. Of course these species are not in zonation, as their mentioning might indicate. More or less intermingling takes place until the area of the oaks is reached. Here, on and about the sandy top of the bluffs, are also such species as Melilotus alba, Verbena stricta, Lespedeza capitata, Strophostyles helvola, Liatris scariosa, Verbena angustifolia, Achillea millefolium, Chenopodium album, Physalis sp. These herbaceous forms are practically all those of dry sandy sites, the so-called waste places. Affinities with the prairie vegetation are to be seen in such as Verbena stricta and Liatris scariosa. More than half the species mentioned belong to the weed class. Melilotus is of general occurrence throughout North America, except in the far north, on sites of this character. The upper layer of this sandy soil on the top of these bluffs appears, hence, to be rather dry, while the deeper soil layers contain much more moisture, at least as judged by the vegetation supported. Upon one of the sandstone cliffs occurring along these bluffs, the small cliffs known locally as "buttes," Pinus strobus occurs sparingly at the verge. Juniperus virginiana, Quercus alba, Q. ellipsoidallis, Q. velutina, small Populus grandidentata, with Carpinus caroliniana and Pyrus melanocarpa were also present on the cliff top. In the oak woods farther back from the river, where the stand of trees is much denser and the soil conditions much better, where in short a later stage of succession has been attained, such an assemblage as the following is representative: Quercus alba, Q. rubra, Q. velutina, Q. ellipsoidalis, Tilia americana, Juniperus virginiana, Hicoria minima, H. ovata, Fraxinus americana, Ulmus pubescens, Prunus serotina. In the undergrowth occur Ostrya virginiana, Cornus paniculata, Xanthoxylon americanum, and so on. The succession has passed in large part from the oak woods stage of the top of the bluffs but still retains many traces of the former. Considerable habitat differences within small areas are here a feature of this.

An extraordinary deviation from the ordinary course of succession in the county today is exhibited by an area outside of that of the Rock River woodlands but worthy of note here because of its developmental relation. In the southwest part of Ogle County on the flat top of a Galena limestone cliff on Pine Creek there are about twenty acres of dense growth of Pinus strobus some seventy to ninety years old. The entire potential area may be said to be approximately a hundred acres or so.

Early settlers state that about 1840 the white pine growth extended irregularly along Pine Creek for a number of miles and reached out in places on either side of the creek, with a number of groups of dense stands like the one remaining. The species is undoubtedly a relic that exists now in the county only in a few small patches or as occasional individuals in inaccessible localities, those unfitted for farming and for grazing, and possibly also such as have been in the past fairly secure from damage by prairie fires.

This Pine Creek stand, whatever its manner of origin, is today and has been for some years past a remarkably strong seedling center. Adjoining it on the east is the customary oak upland woodland of the county. The prevailing winds are from the west and these scatter enormous quantities of pine seed from these vigorous trees to the eastward on favorable seeding ground. But here occurs the stand of upland oaks. It must be observed, however, that these are two extremely different habitats lying alongside each other. The one, on which the pine is growing, is a shallow, residual limestone soil with rock outcrop. The other, on which the upland oaks are growing, is a deep, upland timber soil of yellow-gray silt loam. The former is of much lower soil moisture content.

When the pine stand was of somewhat smaller extent it is probable that some oaks grew on what is now pine area. Perhaps certain small portions, or crevices in the latter, furnished greater soil moisture than the limestone pine area in general, thus permitting the oaks to grow there before they had to meet competition from the pines. The

dissemination of the pine seed has been for some time past and is now so vigorous, however, that it appears to the writer to account, in connection with the other matters recounted here, for the reversal found of the usual course of succession. Here, instead of the pine woods being invaded by the oaks, as usually takes place in the eastern United States, the oak woods are unquestionably being invaded by the white pine along the oak woods-white pine border zone in the territory of the dense white pine stand.

Let us consider now a few localities of the region that are representative of the climax and of certain plant assemblages that are on the other hand removed somewhat from the regular course of succession. In the big bend of the Rock at Grand Detour some herbaceous forms are of interest. This flat, consisting mainly of the terrace soil yellow-gray sandy loam over gravel, with some parts of the bottomland soil mixed loam, and a small area of sandstone rock outcrop, formerly bore a mesophytic woodland with oaks, walnuts, and so on, of large size. The whole area is now under cultivation, except for the part comprising an abandoned channel of an artificial mill stream, and only a border zone of streamside vegetation is present along a portion of the Rock. Some of the herbs in the streamside border and in the cultivated fields are Ambrosia trifida, which is very prominent, A. artemisiifolia, A. ludoviciana, Oenothera biennis, Convolulus sepium, Acnida tuberculata, Silphium perfoliatum, Polygonum pennsylvanicum, Vernonia fasciculata, Brassica sinapistrum, Bidens sp., with many other forms. A large number of the grasses of the county are to be found here as well. Here, in a cultivated area, as in the so-called waste area of the sandy bluff tops west of Grand Detour, prairie forms (such as Silphium perfoliatum and Vernonia fasciculata) and weed forms have found a habitat suitable for their establishment.

The McCormack woods on the east shore of the Rock north of Byron are of great interest. They comprise nearly one square mile, and several parts of the area illustrate the climax form of the Rock River woodland region. One reason for this is unquestionably the fact that these woods have been practically ungrazed for some time. A dozen or

a score of deer have been introduced, but their effects are negligible. The area, too, is one having sufficient topographic diversity to be representative. In the climax expression Quercus alba is still probably the dominant species. The other representative species are Acer saccharum, A. nigrum, Hicoria minima, Prunus serotina, Juglans spp., Tilia americana, Fraxinus spp., Ulmus spp., Quercus platanoides, Populus tremuloides, Quercus ellipsoidalis, Hicoria ovata, Quercus velutina, Populus grandidentata, and some gnarly specimens of Quercus macrocarpa of irregular growth. Ostrya virginiana is very abundant. The undergrowth is notable chiefly from the great variety of shrubs rather than from particularly characteristic species. Most of the shrub species of the region are present. The ground cover consists of mesophytic herbs, such as Asarum canadense, Viola spp., Hepatica spp., Sanguinarea canadensis, and many others. Mesophytic ferns are in great abundance. About the edges and in openings of these woods there are invaders of a xerophytic or xero-mesophytic sort, such species, for example, as Euphorbia corollata, Helianthus hirsutis, Verbena angustifolia, Eupatorium urticaefolium, Campanula americana.

The Heckman woods on the east shore of the Rock just north of Oregon also exhibit in spots the climax form of the region. Here again Quercus alba is the dominant tree species. Quercus rubra is here, however, almost as important. Other tree species are Hicoria ovata, small Fraxinus americana scarcely over five feet in height, Prunus serotina, Quercus ellipsoidalis, Q. velutina, Juglans spp. Acer saccharum, although present, is not yet of any importance in the tree community. The frequent occurrence of species like Hicoria ovata, Quercus ellipsoidalis and Q. velutina, when taken in conjunction with the more mesophytic undergrowth and the quite mesophytic ground cover, indicate clearly that the succession, while advancing towards a mesophytic climax, has not yet reached a full expression of this, since Acer saccharum is negligible and even absent yet in parts. In the more mesophytic undergrowth are such shrubs as Hamamelis virginiana, Xanthoxylon americanum, besides the less representative species of the

region, such as Cornus, Ribes, Ampelopsis, Toxylon, Rubus, Rhus, Vitis, Pyrus. Some small trees, but a few feet in height, of Fraxinus quadrangulata are present. The ground cover is much the most advanced layer, affording the best indication of the approaching mesophytism of the other strata of the vegetation. Here are such herbs as Thalictrum dioicum, Polygonatum spp., Trillium spp., Podophyllum peltatum, Arisaema triphyllum, Caulophyllum thalictroides, and so on. There is a fair assemblage of mesophytic ferns, Aspleniums, Aspidiums, but not so great a display as in the McCormack woods. In this connection it must be noted that here the topography often, even where the mesophytism has advanced to the point just described, furnishes no especially favorable conditions for mesophytism. There are, to be sure, spots where topographic conditions give mesophytic sites, but this area of the Heckman woods has advanced well as a whole towards the climax, and evidently from much less mesophytic oak woods phases of the succession. It has, apparently, been left for some years without noticeable disturbance by grazing or other factors that make for retrogression. The younger tree growth is represented by such species as Fraxinus americana, Prunus serotina, Ulmus spp., Juglans spp., and Hicoria minima, clearly indicating an advance beyond the older tree stand of Quercus alba, Q. ellipsoidalis, Q. velutina, Hicoria ovata. There is evidently greater soil moisture throughout this whole woods than in the ordinary upland woods of the region, and this greater quantity appears to result from the presence of the dense stand of the woodland rather than from any especially favorable topographic arrangement. In some parts of the area Tilia americana, Acer saccharum, Quercus acuminata, Q. alba, Juglans nigra, J. cinerea, Quercus rubra, Hicoria minima, Robinia pseudacacia, occur. The Acer saccharum, though small, still proves clearly what the future of the succession will be if the vegetation continues to be left undisturbed.

The Cartwright woods on the west shore of the Rock north of Oregon, while in places a much confused assemblage of telescoped and condensed stages, nevertheless exhibits the oak-maple climax form excellently over some of

its area. These woods also show well a marked feature of most of the Rock River woodlands, that is, the decided increase in mesophytism in proceeding from portions back from the river towards portions near the river. This is what might in general be expected on an intrenched valley slope. The physiographic diversity, however, occasions many places where this might not be the case. Nevertheless when the vegetative succession is allowed to proceed without disturbance it appears to be quite general. In the Cartwright woods at their western part, that is the portion farthest from the Rock, Quercus macrocarpa is prominent in the stand. Towards the eastern part this species is almost lacking. The increase in mesophytism from west to east is shown by the appearance and increase in numbers of such trees as Juglans nigra, J. cinerea, Ulmus americana. On higher and drier parts of the area, mainly at the western portion, Quercus ellipsoidalis is the chief tree. The more mesophytic eastern part bears the more mesophytic herbs, although in some small areas westward, where especially favorable conditions prevail on account of the topography, such herbs are also prominent. In one part of these woods there occur old trees of Quercus alba, usually with short bole and much branched form. They are quite the oldest trees of these woods. Their appearance suggests that they have belonged to an older stand that was largely open-grown. Into this older stand, presumably, there came the later, present stand of Quercus ellipsoidalis, Q. velutina, Q. alba, Hicoria ovata, and others, from which the still later, more mesophytic, phase of the succession has developed. The species of the climax here do not differ materially from the examples of it already described, except that in these Cartwright woods there is some Betula lutea. This species occurs in a few other places also, being usually present as an expression of certain especially favorable, very localized habitats, rather than as a regular member of the oak-maple climax form.

An extremely mesophytic assemblage representative of the moist areas at the heads of small ravines and other similarly moist areas is shown at the ravine head on the north slope of Liberty Hill back of the town of Oregon. Here

Quercus is perhaps the chief tree. Fraxinus americana and Hicoria minima are prominent. The undergrowth is not remarkable, being about that found in the climax form of the vegetation. Carpinus caroliniana is somewhat prominent, however. Typical mesophytic and hydromesophytic herbs abound, and this, with the fern display, consisting of Osmundas, Aspleniums, Aspidiums, Cystopteris, Adiantum, Polypodium, with a profusion of mosses and lichens on and about the moist sandstone rock wall forming the actual head of the ravine, are especially characteristic.

The island vegetation is another very mesophytic form, but of another sort. Omitting the streamside association the islands generally bear a vegetation about as follows. Ulmus americana and U. Pubescens may be considered the chief trees. Fraxinus nigra, F. americana, Juglans nigra, Celtis occidentalis, Juglans cinerea, Prunus serotina, Acer saccharum, A. nigrum, make up the other prominent species. To these may be added such others of occasional occurrence as Tilia americana, Ailanthus glandulosa, Quercus platanoides. Of course species like Acer saccharinum, Acer negundo, Salix nigra, of the streamside association, are often present as well, back from the borders of the island.

Consequently, from a comparison of the tree species alone, it may be concluded that there is here, in places at least, a telescoping of the climax form with the streamside association, and, on most islands, certain special bottomland or island features, such as the occurrences of Quercus platanoides, or a superabundance of Ulmus. The undergrowth is very similar to that of the oak-maple climax, with, however, much more of liane growth. Often plants of hydromesophytic are combined with plants of xero-mesophytic tendencies, as when, for example, Cephalanthus occidentalis and Crataegus occur near together. Shrubs such as Cornus sericea, Sambucus canadensis, Staphylea trifoliata, are frequent. The ground cover combines herbaceous form of hydrophytic and mesophytic tendencies.

In the Rock River woodland region, as well as one may judge by observation alone, it appears that the main influence on the progression of the plant succession is the soil moisture content. Of course this is the most obvious ele-

ment of the complex, and undue emphasis may therefore easily be given it. Nevertheless, in spite of the obscurity of such factors as temperature and evaporation by observational methods, there seems to be sufficient evidence to regard soil moisture as the prime factor. As the soil moisture content increases the succession here progresses towards the oak-maple climax, and as it decreases the succession retrogresses towards xerophytism, towards something very like what the old prairie groves of the county now are or towards a somewhat less xerophytic form of such woodland. This is without reference in this place to the particular immediate causes.

There has not appeared to the writer to be any marked difference in the vegetation upon soil derived from limestone or sandstone, or, indeed, a difference in the vegetation upon any of the soils of the region that is dependent upon the character of the soil material itself, ergo as sand or lime. Of course on a residual sand, for example, the physical characteristics of such a soil yield in the early stages of plant succession a very different habitat than a clay soil. But these differences are not due to any chemical feature apparently. They are, in later stages of the succession, wiped out completely. It is true that several of the plant species known commonly as those of limestone do occur most frequently on such sites. Pellaea atropurpurea is a notable example. But this fern occurs also on sandstone, even if less frequently. This species with Pellaea gracilis rarely, and with Cystopteris fragilis, C. bulbifera, Woodsia ilvensis, and of course Polypodium vulgare, are the frequenters of rock wall crevices and cliffs. Much of the diversity that appears between sandstone and limestone cliffs seems to be explainable along the Rock and its tributaries by certain other factors. For one thing the sandstone cliffs are mainly along the Rock River, where man's activities have been greatest, and these cliffs present a more xerophytic habitat largely because of such activities. Castle Rock, for instance, on the east shore of the river between Oregon and Grand Detour, composed of nearly white, non-fermuginous sandstone, a very pure silica, is to a great extent without vegetation owing to trampling by visitors.

Other sandstone cliffs, of more remote location, present habitats of advanced mesophytism. This consideration is independent, of course, of high moisture content obtained in some cases, and by a cliff of any sort of material, by peculiarly advantageous seepage conditions related to stratification. Such advantageous moisture conditions frequently are found at the foot of cliffs, and occasionally on their slopes.

While the topographic location of the soil is important in relation to its moisture content, the growth and development of the vegetation itself is of immense importance in determining what the moisture content will be. Before this influence becomes operative in any marked degree the other factors are controlling; the topography, the physical character of the soil, what man has done or is doing to affect the nature of the area. Outside of the Rock River woodland region, out in the prairie groves, a different case obtains. In these isolated woodlots on upland prairie a number of other factors besides that of soil moisture become prominent to differentiate them from the area which is chiefly under consideration in this paper. Factors of a general climatic nature put them in another class. In the woodland region of the Rock it appears to the writer likely that the influences of other factors are largely wiped out and that the influence of soil moisture content dominates.

Any careful examination of the plant life of the Rock River woodland region will bring into notice a phenomenom that appears to be a swinging of the successional trend, now in the xerophytic direction, now in the mesophytic direction, but irregularly. All that is known of the laws of plant succession goes to indicate that, under any particular climatic complex, plant succession will advance to its climax form through various successional stages, unless thrown into retrogression by some external influence. Since the local accounts repeatedly mention marked weather changes in the past, since the advent of white men to the county, and since the whole area is located in a traditional region, one is, at first, strongly inclined to attribute the phenomenon to minor climatic fluctuations, those changes in the weather conditions that present marked minor departures from the

normal over periods of some few decades. Since white men have been in this region only for some eighty years past, no climatic change other than a very minor fluctuation would be traceable, could we obtain weather records for this entire period. Such a record is, of course, not to be hoped for. This swing, which is a thing of the mainland entirely and not of the islands, is seen most clearly in the more advanced phases of succession, say in the white oak-red oak-hickory stage, or some approximately equivalent phase of the successional series, or in a later, more mesophytic, phase. Hereabouts it will become apparent that of two seemingly similar assemblages one is advancing in the mesophytic direction while the other is retreating in the xerophytic. Thus the two assemblages of similar aspect are exhibiting respectively progression and retrogression. This sort of thing may be seen in portions of the Cartwright woods and in areas that are near if not actually in the Heckman woods near Oregon, on the west and the east shores respectively. It seems rather sure that the same occurrence takes place with earlier stages of the succession, but in these it is obscured and would probably require statistical methods to make it clearly evident.

Let us look into the matter of possible minor climatic fluctuations. Accounts are conflicting, but from them all it seems to be believed that about 1880-1900 there were unusually severe winters followed by unusually hot, dry summers, and that, accompanying and following this, great insect damage was done to the foliage of the native vegetation, the tree growth being mentioned particularly. A number of single seasons are spoken of as unusually cold or dry, and so on. Unfortunately information as to plant diseases of the native vegetation in the past is and will probably remain unobtainable. It can only be hoped that at some future time records will be made and preserved of such data both for its intrinsic interest and value and for its application in problems of economic importance. It is now in all consideration of the vegetation an unknown factor.

Another unknown factor, but in this application one that is little mentioned, is that of fires in the woodlands of the

region since the settlement by white men about 1840. Fires, for example, starting at the railroad on the north of the Pine woods in Pine Creek Township, run not infrequently southwards through the area where white pine reproduction generally occurs in the oak woodland adjacent, and are a factor in the successional changes, but here again an uninvestigated factor. There is no evidence, however, in the Rock River woodland region of any such periodical recurrence of fires as would be effective directly or indirectly in bringing about a swing in the successional stages such as has been referred to. The supposed damage to woodland growth by unfavorable climatic changes and plant disease is said to have eventuated economically as follows. The first settlers located themselves in the prairie groves and in the woodland along streams, having a prejudice against the sod of the prairie for farming and also because of the water and the protection from wind afforded by the woods. These early settlers, however, were few in number and did not greatly alter the original extent of the wooded area of the county. Later settlers took up the prairie soil chiefly. Thus the wooded area of the county was preserved without much change in extent until a still later date. Then, according to the local accounts, in about the period of 1880-1900, the damage to tree growth by unfavorable seasons and disease caused much clearing to be made in the wooded areas.

It has been established by meteorologists that no permanent change is taking place in the climate of the country within historic time. Within geologic time periods a change may eventuate. Records available in this country are too short to afford any definite indication of any but short period fluctuations. The longest cover a period of only about 100 years and very few stations have records of more than 50 years in length.

Unfortunately there is no more than some fragmentary records of meteorological conditions in Ogle County. Not far from this county, however, in the same general locality, there does exist one of the oldest and longest series of records for both precipitation and temperature in the entire state. These are for Marengo (formerly Riley) near the

Kishwaukee river in southwestern McHenry County. This is sufficiently close to the Rock River region of Ogle County and sufficiently like it to furnish results for the different seasons (seasonal averages) that are quite comparable. Indeed, it is probable that this McHenry County record furnishes very good information of what the four different seasons of the years involved were throughout the northern part of the whole state. The Marengo records run from 1850 to 1917 for precipitation, with but very few breaks in only three years out of these sixty-eight. The temperature records run from 1856 to 1917, with but very few breaks in only two years out of these sixty-two. For the purposes of this paper seasonal figures have been calculated. The U. S. Weather Bureau practice of calling December of the previous year with January and February of the current year the winter season of the current year has been followed. Then the spring season consists of March, April and May of the current year, with the summer and autumn seasons June, July, August, and September, October, November of the current year. For temperature the means of the four seasons (average monthly temperatures), and the annual means, are given. For precipitation the means of the four seasons (average monthly precipitation), and the annual totals are given. The former is expressed in degrees Fahrenheit and the latter in inches of rainfall. For making these seasonal calculations the records of monthly mean temperatures and annual temperatures, and the monthly precipitation and annual precipitation figures were used.* These monthly figures are not given in this paper, however, since it is believed that, for furnishing data representative of conditions in Ogle County, the seasonal monthly averages are better. The three pages following give this data for the different years in tabular form. As a sort of norm for the comparison the following average monthly precipitation figures for the different seasons have been calculated from published data,** for the northern central portion of Illinois.

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*Monthly Wea. Rev. Washington, Feb. 1888, p. 53.
Ill. Climate & Crops Rep. s. 1901-1910.
U. S. Wea. Bur. Climatological Data, 1910-1917.
U. S. Wea. Bur. Springfield, Ill., Records 1888-1900.

**Kincer, J. B.: Seasonable distribution of precipitation and its frequency and intensity in the U. S. Month. Wea. Rev. 47:624-31, 1919.

Average monthly precipitation in winter 1.3—2.0 inches
do in spring 2.7—3.3
do in summer 3.3—4.0
do in autumn 2.7

PRECIPITATION
(Inches)

YEAR	Seasonal Monthly Means Winter Dec. prec. yr. Jan. Feb. curr. yr.	Spring Mar. Apr. May	Summer June, July Aug.	Autumn Sept. Oct. Nov.	Annual Totals
1850	——	2.8	10.1	3.1	53.1
1851	2.5	6.5	7.0	2.8	56.9
1852	2.3	6.0	2.2	3.4	42.0
1853	2.5	4.0	4.9	4.5	45.4
1854	1.3	——	——	——	——
1855	——	——	9.1	2.2	——
1856	2.2	2.8	2.5	2.6	31.4
1857	3.2	3.7	4.5	2.3	38.0
1858	0.8	4.7	7.1	4.5	50.3
1859	1.6	3.9	1.7	3.0	29.8
1860	1.0	2.6	3.2	2.8	29.9
1861	1.6	3.8	3.5	3.4	36.6
1862	3.3	2.3	2.5	2.4	41.1
1863	1.8	2.4	1.8	2.2	25.6
1864	1.1	1.9	2.9	2.0	23.9
1865	3.1	2.1	5.8	2.1	37.2
1866	0.7	2.3	5.7	3.6	39.9
1867	2.2	2.6	4.3	1.2	27.9
1868	1.1	5.2	5.0	3.6	44.8
1869	1.9	3.0	6.7	2.0	42.5
1870	1.9	2.2	3.1	3.1	29.5
1871	1.9	2.2	3.1	2.3	27.8
1872	0.9	3.2	3.6	3.7	33.3
1873	1.1	3.1	2.4	2.0	28.4
1874	2.4	2.0	2.3	2.1	24.4
1875	1.3	2.2	3.9	3.6	34.7
1876	4.5	6.3	5.7	6.7	72.8
1877	2.5	3.1	3.5	3.2	34.5
1878	1.9	3.3	3.6	2.4	32.4
1879	1.6	2.6	4.2	2.6	32.6
1880	2.4	2.4	4.1	2.5	33.3
1881	2.5	3.5	4.2	4.6	47.2
1882	2.1	3.8	3.4	2.7	35.4
1883	2.9	3.0	2.7	3.5	35.9
1884	1.6	2.3	3.9	3.3	35.0
1885	2.5	2.0	4.9	2.8	35.8
1886	2.5	3.5	2.9	1.9	31.2
1887	3.2	1.2	2.9	3.1	33.2
1888	1.9	3.0	2.6	1.6	26.4
1889	1.6	2.7	2.5	1.5	24.5
1890	1.9	3.1	4.7	2.6	36.4
1891	1.7	3.4	3.1	1.9	31.3
1892	1.7	5.1	6.5	0.9	43.2
1893	1.6	2.8	2.6	3.0	30.0
1894	1.7	3.1	1.0	6.5	35.5
1895	1.0	2.0	3.0	1.8	25.9

PRECIPITATION—Continued

(Inches)

YEAR	Seasonal Monthly Means Winter Dec. prec. yr. Jan. Feb. curr. yr.	Spring Mar. Apr. May	Summer June, July Aug.	Autumn Sept. Oct. Nov.	Annual Totals
1896	1.7	3.3	2.8	3.9	32.5
1897	2.1	2.5	2.3	1.4	25.2
1898	2.8	3.1	4.8	2.4	38.7
1899	0.8	2.3	3.1	1.6	24.2
1900	2.1	1.9	5.2	2.4	33.7
1901	1.2	1.6	2.3	1.3	19.7
1902	1.0	3.3	5.2	3.1	39.1
1903	1.5	3.4	4.3	3.1	35.9
1904	1.6	3.0	2.7	2.1	28.0
1905	1.3	4.5	5.8	3.0	40.7
1906	2.0	2.0	2.7	2.8	28.6
1907	1.8	3.0	4.4	2.2	34.2
1908	1.5	5.0	2.9	1.0	31.8
1909	2.0	3.5	3.4	2.7	38.8
1910	2.6	2.7	1.9	1.8	22.5
1911	1.3	2.4	3.9	3.8	34.9
1912	1.0	2.1	5.3	3.6	35.3
1913	1.3	3.4	4.1	2.7	33.7
1914	1.0	3.5	3.1	2.4	31.6
1915	1.7	2.4	3.7	2.8	30.5
1916	1.8	2.9	3.8	3.8	38.7
1917	1.4	2.6	2.6	——	——

TEMPERATURE

(Fahr.)

YEAR	Seasonal Monthly Means Winter Dec. prec. yr. Jan. Feb. curr. yr.	Spring Mar. Apr. May	Summer June, July Aug.	Autumn Sept. Oct. Nov.	Annual Means
1856	——	46.2	72.7	49.7	46.1
1857	17.7	39.7	71.5	48.0	45.6
1858	28.0	63.3	73.0	49.7	48.9
1859	25.7	45.8	68.8	59.1	46.4
1860	20.6	46.4	67.2	46.3	45.7
1861	23.0	44.0	66.4	47.4	46.0
1862	22.8	43.1	68.0	48.8	45.6
1863	28.0	46.8	68.1	49.8	47.1
1864	23.9	45.7	71.2	47.1	46.1
1865	21.0	48.3	67.3	53.1	47.3
1866	19.7	44.1	69.1	48.4	45.6
1867	21.0	40.3	75.1	51.2	46.2
1868	18.9	46.1	71.4	45.4	45.1
1869	20.7	42.6	67.5	43.0	44.7
1870	22.8	47.6	70.9	50.9	47.9
1871	22.8	48.2	68.6	46.0	45.9
1872	18.7	42.2	70.1	44.9	43.6
1873	14.1	41.9	70.4	43.3	43.6
1874	23.1	41.6	70.9	48.1	45.7
1875	11.2	40.9	66.0	43.2	40.9
1876	27.0	43.5	69.6	45.0	44.6

TEMPERATURE—Continued

(Fahr.)

YEAR	Seasonal Means: Winter Dec. prec. yr. Jan. Feb. curr. yr.	Spring Mar. Apr. May	Summer June, July Aug.	Autumn Sept. Oct. Nov.	Annual Means
1877	17.9	——	68.1	48.7	——
1878	31.1	48.7	69.4	48.2	47.5
1879	15.7	45.9	69.4	49.2	45.5
1880	26.9	46.8	69.7	42.7	46.2
1881	14.3	43.4	69.9	49.9	45.6
1882	27.8	42.8	66.6	50.1	45.7
1883	14.3	41.3	63.4	46.1	42.4
1884	17.9	43.3	66.4	49.8	44.0
1885	16.4	40.5	66.9	46.8	41.8
1886	18.5	45.2	68.7	47.9	44.4
1887	16.0	46.2	70.7	45.0	45.1
1888	15.9	40.5	67.8	46.3	43.1
1889	22.5	46.1	64.3	46.3	46.2
1890	30.1	41.7	68.7	48.4	46.3
1891	25.5	43.7	66.5	49.3	46.7
1892	24.6	42.2	68.5	48.1	44.8
1893	13.6	39.4	69.9	48.7	43.2
1894	20.9	48.4	72.2	48.4	48.2
1895	18.2	46.1	70.9	47.5	45.4
1896	24.4	49.2	69.9	46.8	47.6
1897	24.1	44.2	69.4	53.2	47.1
1898	22.5	47.4	71.2	47.5	47.7
1899	18.5	46.2	72.3	53.5	48.0
1900	22.1	45.7	71.6	53.2	48.4
1901	20.8	45.9	73.9	50.3	47.2
1902	20.4	48.3	67.4	52.4	47.5
1903	21.9	49.6	67.1	49.4	46.5
1904	14.6	44.4	68.1	51.7	45.2
1905	16.8	47.3	69.4	51.2	46.6
1906	26.3	45.3	70.6	55.3	48.6
1907	24.5	43.8	68.8	48.9	46.5
1908	24.5	47.6	69.4	53.3	48.6
1909	26.5	43.8	70.1	51.1	47.0
1910	18.1	50.0	71.7	49.7	47.8
1911	24.0	48.2	71.7	48.7	48.8
1912	17.4	44.2	68.1	51.9	45.3
1913	24.7	45.6	71.2	52.1	48.7
1914	25.6	47.4	71.0	53.5	48.1
1915	21.8	46.6	65.2	52.3	47.0
1916	22.9	45.0	71.2	50.0	47.0
1917	27.0	43.6	67.6	——	——

The precipitation figures given in the table will show the amount of departure from the general average conditions for the northern central portion of Illinois. For temperature the table figures themselves furnish ample comparison for normal and abnormal conditions.

Examining the annual figures for precipitation only nine or ten years out of the whole sixty-eight show marked variation from the normal. The years 1863, 1864, 1874, 1889, 1895 (possibly), 1897, 1899, 1901 (with a total annual precipitation of only 19.7 inches, which is phenomenally low in a region where normally there is around 30 to 35 inches) and 1910 are the ones with low annual precipitation.

The statement has been made that "since 1885 the rainfall has decreased" in the Rock River watershed as a whole.* To test this for the northern part of Illinois the figures for annual precipitation have been added for five year periods both before and after 1885, the data furnishing six of each, and the average annual precipitation for each of such periods calculated. These data are as follows:

Period	Average Annual Precipitation	Totals
1856—1860	35.9 inches	
1861—1865	32.9	
1866—1870	36.9	
1871—1875	29.7	214.4 inches
1876—1880	41.1	
1881—1885	37.9	
1886—1890	30.3	
1891—1895	33.3	
1896—1900	30.9	
1901—1905	32.7	191.5 inches
1906—1910	31.2	
1911—1915	33.2	
		22.9 inches

This would indicate that there had, indeed, been a slight decrease in the total annual precipitation since about 1885. But an examination of the figures for the separate years shows that the year 1876, which falls, of course, within the first period — that before 1885 — had a most phenomenally high annual precipitation, a total for the year of 72.8 inches. If the difference between this and an

*Schwarz, G. F.: The diminished flow of the Rock River in Wisconsin and Illinois. U. S. Dept. Agric. Bur. of For. Bul. 44, 1903, Page 8.

assumed general average of 35 inches for the year, which would be a high general average, be taken, the figure of 37.8 inches is obtained. If this excess of over 35 inches for the phenomenal year 1876 be deducted from the total for the period before 1885 this whole period becomes of the same magnitude as that of the period after 1885. Further, the year 1901, of the latter period, was phenomenally dry, having a total annual precipitation of only 19.7 inches. Consequently it does not appear, on the whole, safe to say that there has really been any change in the rainfall of this region of northern Illinois in more than a half century.

An inspection of the seasonal monthly means of precipitation shows considerable deviation from the normal in a number of single years for each of the four seasons, but there does not appear any change running over a series of years for any of the seasons, within the total period for which data exist. The winters of 1858, 1866, 1872 and 1899 show low precipitation, while those for 1876 (which was a year of very phenomenally high precipitation throughout all the four seasons), and 1887 show high precipitation. With the exception of the phenomenally low precipitation of the year 1901 the growing seasons (spring and summer) of the different years show rather a number of individual years with amounts above the usual than years with amounts below. The period 1850-1853 appears to have had unusually high precipitation for the growing seasons. The remaining years with unusually high precipitation are scattered, 1858, 1865, 1866, 1868, 1876, 1892 and 1905.

Examining the annual figures for temperature, the annual means, a remarkably harmonious series is discovered. For the whole period of sixty-two years the greatest difference, that between the maximum and the minimum annual mean, is only 8 degrees. The winters of 1879, 1881, 1883-1888 inclusive were unusually cold, but the remaining seasons of these years presented nothing abnormal in the way of average monthly seasonal temperatures. Unusually low precipitation followed for the summers of the years 1883. 1886, 1887 and 1888, while the spring of the year 1887 also had unusually low precipitation. It is about this period that the damage to native vegetation, so often referred to

in the county, was said to have occurred, along with the extremely dry year 1901, when the temperature, however, throughout all four seasons presented nothing abnormal. The seasonal monthly means for the remaining seasons present remarkably uniform figures.

It is, therefore, evident that there is nothing in the way of climatic fluctuation of a periodic nature within the last fifty or sixty years at least within the region of the Rock River woodland and thereabouts to account for any swinging of the successional trend between the xerophytic and the mesophytic directions. The only marked feature would be that of the rather unfavorable years of about 1879-1888, when even then, not all of these were sufficiently unfavorable to afford sufficient reason for much effect upon the native vegetation. The effect, especially if aided by plant disease of insect attack history, would be retrogressive. Recovery from such a setback would mean a return to the former rate of progression, or something approximating it. A lag in the response of the plant associations would probably alter the dates somewhat for vegetative changes.

The writer believes, however, that it is not any climatic change, and probably not materially any plant disease attack, that is mainly responsible for the seeming swinging of the succession, nor for the marked alterations in the nature of the native plant growth of the county. A general observation only of the Rock River woodland region would, it is believed, lead one at first to the conclusion that, instead of any swinging of the successional trend, there is a pronounced movement in the xerophytic direction. Closer observation and the consideration given to the climatic data available bring the writer to the conclusion that the affair is related mainly to man's interference with the native vegetation. Where the activities of man have caused interference, there retrogression of the vegetative succession has occurred and occurs today. Where man has not interfered in the past with the native vegetation, there it has advanced in the mesophytic direction, that is to say progression of the vegetative succession has occurred. And whenever man has, after such interference, ceased his re-

trogression-causing activities, there progression of the vegetative succession has been resumed. The potentiality of the region for advanced stages of the vegetative succession has remained unchanged, except in so far as the activities of man may have permanently altered this. Those dealing with genetic plant geography would probably all agree that the glacial ice advance was a catastrophic event in the history of vegetation. To a lesser degree, but to how much less is uncertain, the advent of white men and their brief stay of less than a hundred years in this region has been absolutely catastrophic in its effect upon the native vegetation. Not the speed of the reaction chiefly but the degree of the effects is important. And it has been practically wholly retrogressive. It must be remembered that here the discussion is concerned wholly with matters of plant life separate from all economic questions. The economic desirability of the proper handling of woodland growth, of grazing, and so on, is, of course, absolutely unquestionable.

There are many evidences in the Rock River woodland region of the disastrous effects on the native vegetation of the clearing of wooded areas. On the west side of the Rock, in the upland timber soils especially, gullying is so common in farm fields that frequently makeshift measures to stop or reduce the damage are encountered. It is of common occurrence on both the west and the east sides of the river to find during the summer many small streams with dry beds, streams giving evidence in the nature of their cutting and in the dead or passing vegetation of their banks of having once been fairly permanently watered. Then, too, in a few places, where such small streams are still protected in their flow by wooded areas, they are found with running water throughout the summer. It seems certain that, allowing for all natural exaggeration in the early accounts, in the early days of white settlement and for unknown years before that time the prairie fires were a factor of prime importance in the development of the native vegetation of the region. The early records of Ogle County are one with the records of similar sections of the country in

recounting the ravages of such fires. They cannot be accounted as having been less than catastrophic in their nature.

Today, however, the factor of man's activities that appears to be that most actively operative is the grazing of domestic stock in woodland areas. About the entire gamut of grazing is being run—cattle, horses, pigs, sheep, goats, and deer. It is extremely rare to find any place where grazing is practiced where the number of grazed animals has been held down to such a number as would cause little or no deterioration of the fodder plants, not to speak of the native vegetation as a whole. The consequence is that not only has the grazing been impaired but the productiveness of the land itself has become impaired, except where it was shortly converted into farm crop land. Back from the Rock River in many or most of the farm woodlots, where, apparently, the purpose is to obtain permanent pasturage for domestic stock, the areas have been so reduced and impaired by overgrazing as no longer often to afford pasturage, having been reduced merely to shaded places for stock.

The effect of all these matters, when considered from the point of view of their action on the habitats involved, is believed by the writer to be chiefly of an edaphic nature, a matter of affecting the soil moisture content. For more complete elucidation of the numerous questions involved the line of attack would have to be a series of investigations planned for quantitative work. On the basis of data furnished by observational investigations such further questions might be determined.

Perhaps it will some day be recognized generally in this country that, as the elder Cockayne, a foreign botanist, has said—"The yield per acre in crop or meat is primarily a matter of the plant covering of the farm," that "facts based upon the study of a virgin vegetation and on that of an artificial or modified vegetation are of equal value, the same laws governing both," and that, hence, "the ecology of virgin land is, then, the ecology of the farm, except that on the latter man can purposely alter the conditions to which the plants are subject in order to increase their economic effi-

ciency." "Agriculture is neither more nor less than applied plant and animal ecology." Although the present investigation has been one wholly separate from all economic questions, being one entirely in pure plant ecology, it is evident that in the near future many similar investigations will need to be undertaken in the field of applied plant ecology.

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Papers on Geology and Geography

NEW SPECIES OF DEVONIAN FOSSILS FROM WESTERN ILLINOIS

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The Devonian limestones of Rock Island County, Illinois, were deposited in a basin that was connected northwestward with the Arctic Ocean, and are said to belong to the northern or Interior Continental province. They are an eastward continuation of the Devonian limestones of eastern Iowa, with which they entirely correspond. These limestones in Iowa were described by Owen[1] in 1852 as "The limestones along Cedar Valley[1]", and he considered them equivalent to the upper Helderberg (Onondaga) and Hamilton formations of the New York section.

James Hall[2] in 1858 also referred the Devonian limestones in Iowa to the upper Helderberg (Onondaga) and Hamilton formations.

In a report on the Geology of Iowa in 1870 White[3] assigned all of the Devonian limestones of Iowa to the Hamilton formation, under which name the strata were described.

Three years later Hall and Whitfield[4] restudied the Devonian Limestones of Iowa and correlated the limestone in the vicinity of Waterloo with the upper Helderberg (Onondaga); the white limestone near Raymond with the Schoharie; and the limestones at Waverly and Independence with the Hamilton of New York.

In 1878 Calvin[5] referred the Devonian limestones in eastern Iowa to the Hamilton formation.

Barris,[6] who had studied the Devonian limestones in the vicinity of Davenport and Rock Island, reported one or more unconformities in those beds and considered the upper limestones of that region equivalent to the Hamilton of New York, and the earlier Devonian limestones to the upper Helderberg (Onondaga).

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1 Owen, D. D., Rept. Geol. Surv. Wis., Iowa and Minn., pp. 77-89, 1852.
2 Hall, James., Geol. of Iowa, Vol. I, pt. I, pp. 81-88, 1858.
3 White, C. A., Geol. of Iowa, Vol. I, p. 109, 1870.
4 Hall, James and Whitfield, R. P., 23rd. Ann. Rept. of Regents of N. Y. State Cabinet, pp. 223-226, 1873.
5 Calvin, Samuel, Am. Jour. of Science, 3rd ser. Vol. 15, pp. 460-462.
6 Barris, James, Proc. Davenport, Acad. of Science, Vol. 2, pp. 261-269 and 282-288, 1870.

In volume I. of the reports on the Geological Survey of Illinois Worthen[7] referred the Devonian limestones of Rock Island County, Illinois, to both the upper Helderberg (Onondaga) and the Hamilton formations. In discussing the Geology of northeastern Iowa in 1891 MaGee[8] considered the Devonian limestones as a unit and revived the name "Cedar Valley limestones" applied by Owen to these strata more than 40 years before. MaGee proposed to distinguish the lower, brecciated member of these limestones as the "Fayette breccia" from the town of Fayette, Iowa, where they are well exposed.

The same year Calvin[9] gave the name Gyroceras beds to the strata a few feet in thickness lying immediately above the brecciated limestones containing many Gyroceroid shells.

In 1895 Norton[10] proposed the name Wapsipinicon limestone for the Devonian strata included in the Fayette breccia of MaGee, and the Gyroceras beds of Calvin, from the Wapsipinicon River in eastern Iowa where these rocks are well exposed. He restricted the name Cedar Valley limestone to the more shaly and very fossiliferous strata, that occur above the Gyroceras beds in eastern Iowa. Norton[11] also divided the Wapsipinicon limestone into the following members: Otis beds at the base; Kenwood shale; Lower Davenport limestone, equivalent to the Fayette breccia of MaGee; and Upper Davenport limestone, corresponding to the Gyroceras beds of Calvin. This classification has generally been followed by the Iowa Geological survey. Weller[12] has considered the Wapsipinicon limestone of Iowa in the main equivalent in time to the later Hamilton of the New York section and the Cedar Valley limestone about contemporaneous with the Portage group of New York.

The writer[13] has recently correlated all of the Cedar Valley and Wapsipinicon limestones of Iowa and Illinois about

7 Worthen, A. H., Geol. Surv. of Illinois, Vol. 1, p. 120, 1866.
8 MaGee, W. J., Eleventh Ann. Rept. U. S. Geol. Surv., p. 319, 1891.
9 Calvin, Samuel, Am. Geologist, Vol. VIII, p. 142, 1891.
10 Norton, W. H., Iowa Geol. Surv., Vol. IV, p. 155, 1895.
11 Norton, W. H., Proc. Iowa Acad. of Science, Vol. I. pt. 4, pp. 22-24, 1893.
12 Weller, Stuart, Outlines of Geological History with Especial Reference to North Am., p. 101, 1910.
13 Savage, T. E., Devonian Formations in Illinois, Am. Jour. of Science, 4th Ser., Vol. 49, Mch., pp. 181 and 182, 1920.

with the Tully limestone of the New York section. The Wapsipinicon and Cedar Valley limestones are both present in Rock Island County, Illinois, and the following members of the Wapsipinicon limestone are recognized in that region: Otis beds; Lower Davenport limestone; and Upper Davenport limestone.

WAPSIPINICON LIMESTONE

The Otis Beds outcrop on Campbell's Island in the Mississippi River above Moline, and a few low exposures occur in the Illinois bank of the River in that vicinity. This is gray to dark non-magnesian limestone, commonly rather fine grained, and somewhat irregularly bedded. The thickness does not exceed 15 or 20 feet. It is succeeded in this region by the Lower Davenport limestone without any trace of the Kenwood Shale. The Lower Davenport member consists of strongly brecciated nonfossiliferous limestone, the fragments of which are gray to dark, fine grained, and show fine laminations on weathered surfaces. The matrix is also fine grained, but is somewhat lighter in color. This brecciated limestone is exposed in the Government Island at Rock Island, and is the horizon formerly quarried in Rock Island and Moline. The Lower Davenport limestone is overlain in apparent conformity by the Upper Davenport member which is composed of gray, granular, subcrystalline limestone, in irregular layers from a few to twelve inches or more in thickness, and contains several fossils, among which Phillipsastrea billingsi, Diplophyllum major, Schizophoria macfarlanei, Gypidula comis, and several Cephalopod species are characteristic. This member is well exposed in the vicinity of Sears and Milan.

CEDAR VALLEY LIMESTONE

The Cedar Valley limestones are commonly more shaly, more evenly beaded, and more richly fossiliferous than those of the Wapsipinicon which they succeed without any sedimentary break. They outcrop in the banks of Mill Creek, and farther west along several of the creeks both east and west of Andalusia. These limestones are commonly rather thin bedded, shaly and obliquely jointed in the lower part.

The Acervularia coral reef is near the middle, above which the layers are mostly limestone or dolomite. The total thickness of the formation is nearly 70 feet.

The general succession and relations of the Devonian rocks in Rock Island county are shown in the following section:

Generalized section of the Devonian rocks in the vicinity of Rock Island, Illinois:

		Feet
CEDAR VALLEY LIMESTONE.		
10.	Dolomite, yellowish-gray to brown, in layers 6 to 24 inches thick, alternating with thinner partings of shale, containing many stromatoporoids and other fossils. Exposed along the creeks both east and west of Andalusia	20
9.	Limestone, thin bedded, gray, with partings of shale, containing many stromatoporoids, Stropheodonta demissa, Schizophoria iowensis, Athyris fultonensis, Atrypa reticularis (large shells), Gomphoceras cf. ajax, and other fossils. Exposed near the mouths of a few streams near Andalusia	4
8.	Dolomite, yellowish-gray, in layers 12 inches or less, containing Cystodictya hamiltonesis, Athyris fultonensis, Spirifer asper, S. subvaricosus, Cyrtina hamiltonensis, small shells of Atrypa reticularis and other fossils	6
7.	Limestone, the upper 1½ feet the Acervularia davidsoni coral reef. The lower part is an organic breccia which in places projects by intersecting vertical plates into the underlying layer. Exposed in the bank of the river below Andalusia, and in the bank of Mill Creek near the center of Section 25, T. 17 N. R. 2 W.	8
6.	Limestone, impure, bluish-gray, crinoidal, thin bedded, containing Cladopora iowensis, Megistocrinus latus, Chonetes scitulus, Leptostrophia perplana, Spirifer asper, S. iowensis, S. subvaricosus, Cyrtina umbonata, and other fossils. Exposed at the most of the localities where the overlying coral reef outcrops	5
5.	Limestone, blue, argillaceous, fine grained, with very oblique and prominent jointing. Containing Spirifer iowensis, S. subvaricosus, Cyrtina umbonata, Atrypa aspera var. hystrix, and other fossils. Exposed along Mill Creek; and in the quarries near Linwood and Buffalo, in Iowa	20
4.	Limestone, fine-grained, rather thin bedded, with shaly partings, containing Acervularia profunda, Favosites alpenensis, Schizophoria iowensis, Pentamerella dubia, Productella subalata, Spirifer asper, S. bimesialis, and S. iowensis. Exposed in the quarries and ledges in Rock Island, Sears and Milan	5
WAPSIPINICON LIMESTONE.		
	Upper Davenport Beds.	
3.	Limestone, hard, gray, in imperfect layers 6 to 24 inches thick, containing Astraeospongia hamiltonensis, Chonophyllum cf. magnificum, Diplophyllun major, Phillipsastrea billingsi, Spirifer subundiferous, and other fossils, exposed near the railroad bridge across Mill Creek, and near the wagon bridges across Rock River. This is the horizon formerly worked in the old quarries in Milan and Rock Island	8

PLATE I.

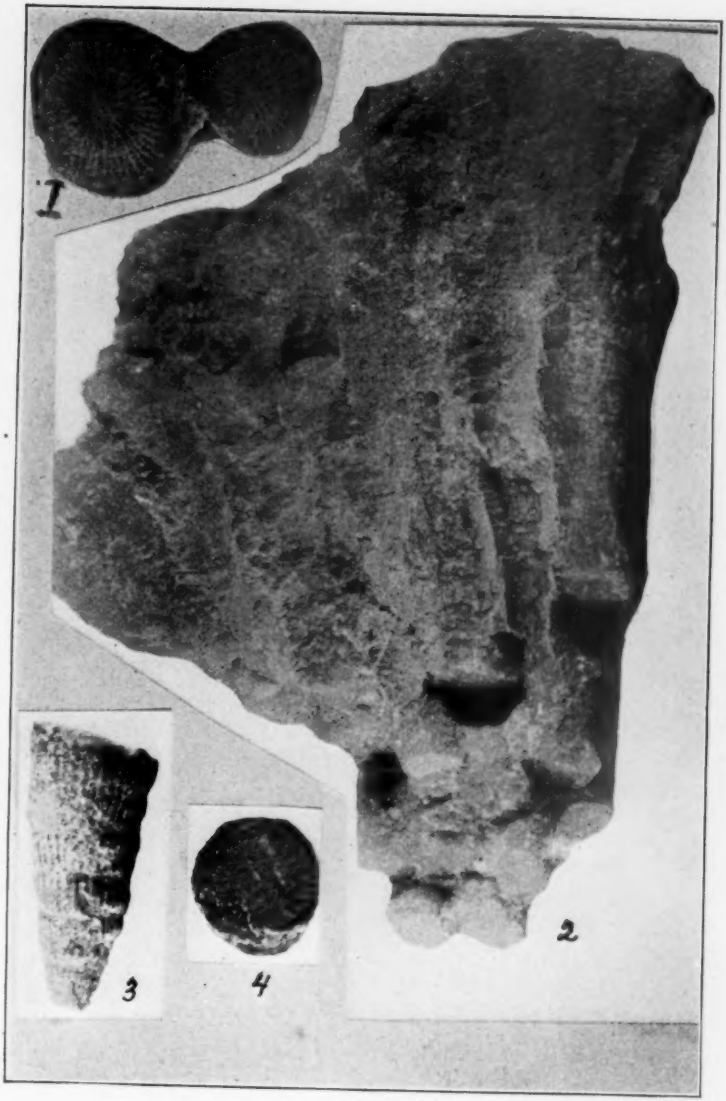

PLATE II.

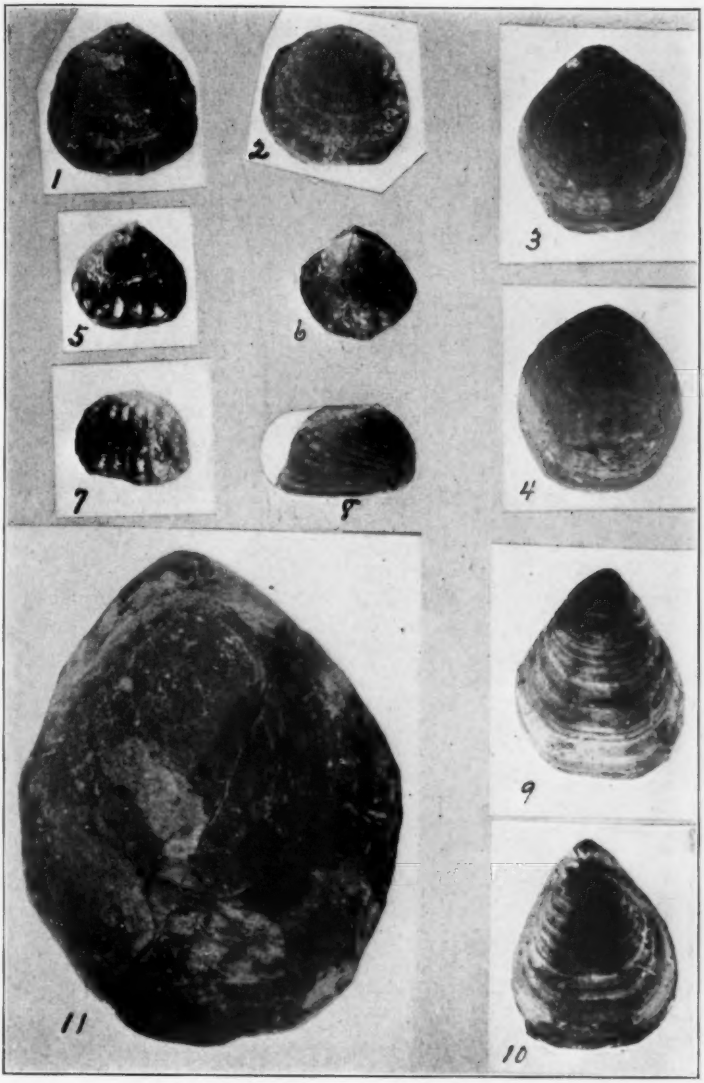

PLATE III.

PLATE IV.

Lower Davenport Beds.

2. Limestone, white to dark gray, fine grained, in layers ½ to 3½ feet thick, with few fossils, in places finely laminated, usually much fractured and brecciated, with fragments 1 to 24 inches in diameter. Exposed in the Cady quarries in East Moline, in the the Government Island, in the south bank of Mississippi River in Rock Island, and forms the bed rock in Rock River valley between Milan and Sears—fossils few or none..... 55

OTIS LIMESTONE.

1. Limestone, light to dark gray, fine grained, not brecciated, in irregular layers, containing spherical concretions of chalcedonic quartz, and numerous shells of Martinia subumbona. Exposed on the east side of Campbell's Island above Moline, and in the east bank of Mississippi River opposite the island..... 20

ZAPHRENTIS PUTILLA N. SP.

Plate I, Figures 3 and 4.

Description:—Corallum simple, conical straight or slightly curved, sub-circular in cross-section, diameter increasing gently and at a rather uniform rate from the apex. Surface marked by rather distinct septal furrows, and by occasional transverse wrinkles, or ridges and depressions, which are usually small; rim of calyx thin, very little oblique; the calyx moderately deep contracted below, with a rather large fossula; major septa commonly about 24, ranging from 20 to 30, depending on the size or age of the corallite, their inner extremities nearly or quite reaching the center; alternating with the major septa are an equal number of low, secondary, septa which are sometimes scarcely more than septal ridges.

The dimensions of two individuals are: Length 20 to 30 mm., diameter of calyx 10 to 14 mm.

This species differs from most species of Zaphrentis in its small size, the slight, if any, curvature, and the very gradually expanding corallum. It lacks the pseudecolumella or vesiculose central area of Stereolasma rectum Hall, and Streptelasma strictum Hall, with which it most nearly corresponds in size. It is distinguished from Zaphrentis calcareforme in that the shorter septa do not join the longer, and the latter are not united with the wall of the fossula.

Horizon and Locality:—Common in the Cedar Valley limestone along Mill Creek, near Milan, where it occurs a few feet below the Acervularia coral reef.

DIPLOPHYLLUM? MAJOR N. SP.

Plate I, Figures 1 and 2.

Description:—Corallum compound, in rather dense masses 1 to 2 feet in diameter. The corallites are cylindrical, more or less parallel, nearly contiguous or separated from one another by a distance less than the width of the corallites, not connected by prolongations of the epitheca, circular in cross section, varying from 8 to 12 mm. in diameter; marked on the surface by indistinct longitudinal lines resembling septal ridges, and also by fine transverse lines, and rather strong annulations and constrictions. The calyx is moderately deep, septa about 40, more or less undulating, half of them longer than the others and joined together irregularly at the center, or uniting near the center, to form an inner ring or wall surrounding a small central area. The alternate or secondary septa are shorter than the primary ones, and extend slightly more than half the distance from the periphery to the center; the disseppiments are numerous, and the septa carinated in the outer zone through which both sets of septa extend; a few disseppiments are present in the more open, central zone penetrated only by the longer septa. A few of the corallites —about 1 out of every 5 in the same corallum,—show a small central area about 1 millimeter in diameter surrounded by a distinct wall formed by the

coalescence of the inner edges of the longer septa, the other four-fifths of the corallites show no such central area, the inner edges of the longer septa uniting irregularly in the central part of the corallite without forming a definite ring.

Horizon and Locality:—Common in the upper part of the Wapsipinicon limestone in the vicinity of Milan, where it is associated with Phillipsastrea billingsi, Gypidula comis, and the cephalopods described on a later page of this paper.

RHIPIDOMELLA MINIMA N. SP.

Plate II, Figures 1 and 2.

Description:—Shell small, biconvex, length and width about equal, the greatest width anterior to the middle; hinge line about equal to ½ the greatest width of the shell; the cardinal extremities rounded. Ventral valve most convex in the umbonal region from which the surface curves rather abruptly to the cardinal margin, and more gently to the lateral and anterior margins; without trace of mesial fold or sinus, beak small, extending only a short distance above the hinge line; cardinal area small, concave, its margins sharply defined; delthyrium rather broadly triangular. Dorsal valve not quite so convex as the ventral, the greatest convexity posterior to the middle from which the surface slopes gently in all directions, the median portion of the valve depressed into a distinct sinus which begins near the beak, and becomes stronger anteriorly but is poorly defined laterally; the beak is small, not incurved; cardinal area very narrow, lying almost in the plane of the valve.

The surface of both valves marked by numerous radiating striae which begin near the beak, and bifurcate 3 or 4 times before reaching the front margin where about 3 are present in a distance of one millimeter. These striae are strongest and subangular on the unbones, decreasing somewhat in size towards the front. A few concentric lines of growth are present near the front and lateral margins.

The dimensions of the shell are: Length 8 to 11 millimeters, greatest width 8 to 11 millimeters, thickness 3 to 3.5 millimeters.

Remarks:—In the small size, and in the mesial sinus of the dorsal valve this species resembles Rhipidomella jerseyensis described by Weller from the Kinderhood of Illinois and Missouri. It differs from that form in its typically smaller size, the more nearly circular outline, the more angular and stronger striae on the unbones, and the fewer and coarser striae over the surface of the shell, the more concave or arched cardinal area of the vertical valve, the less compressed cardinal extremities, and the more rounded front margin which is not emarginate.

From Rhipidomella dubia (Hall) it is distinguished by the broader posterior portion, more circular outline, longer hinge line, and the presence of a mesial sinus in the dorsal valve, and its absence in the ventral.

From R. tenuicosta Weller from the Kinderhook our species differs in having coarser striae, and a more distinct mesial sinus in the dorsal valve.

Horizon and Locality:—Common in the Cedar Valley stage of the Devonian, along Mill Creek, near Milan, where it occurs a few feet below the Acervularia davidsoni coral reef.

PUGNOIDES SUBOVATA N. SP.

Plate II, Figures 5, 6 and 7.

Description:—Shell broadly subovate to subtrigonal in outline, width and length about equal, the greatest width slightly anterior to the middle of the shell. The dimensions of 6 individuals range as follows: Length 8 to 10 mm., width 8 to 10.5 mm., thickness 5 to 8 mm.

The ventral valve is less convex than the dorsal except at the front, the postero-lateral margins nearly straight, and meet at the beak at an angle of nearly 90 degrees, the lateral and anterior margins rounded; the surface is convex in the umbonal region, curving abruptly to the postero-lateral margins, and less abruptly in the antero-lateral portion. The beak is pointed, not greatly

produced beyond that of the dorsal valve, only slightly incurved, closely appressed over the beak of the opposite valve so as to conceal the foramen; mesial sinus obsolete in the posterior part of the shell, but becomes rather broad and deep in the anterior portion where it is produced in a rather broad linguiform extension that curves strongly towards the dorsal valve. The anterior part of the shell bears low, rounded plications of which 3 to 5 are depressed in the mesial sinus, on each side of which 3 weak ridges are visible for a short distance on the antero-lateral slopes.

Dorsal valve more convex than the ventral, the greatest convexity along the middle part, from which the surface curves rather steeply to the postero—and antero—lateral margins, and much less strongly towards the front margin; a broad, low, mesial fold appears in the posterior half of the shell, becoming well defined, and distinctly elevated at the front where it receives the extension of the opposite valve; near the front are a few low, rounded radiating ridges, 4 to 6 of which are elevated on the mesial fold which is well defined, and is bordered on each side by 2 or 3 weaker ridges, none of which extend to the middle of the valve.

Besides the short, low, rounded, radiating ridges and furrows, the surface is marked by numerous fine concentric lines which are visible with a lens; a few stronger lines of growth are also usually present.

Remarks:—This shell is easily distinguished from Pugnoides pugnus, and Pugnoides pugnus var. alta, in the weak and rounded character of the radiating plications, in which characters it more closely agrees with forms like Pugnoides ottumwa of the Ste. Genevieve limestone, of Mississippian age. It differs from the latter species in being much shorter and thicker in proportion to its length.

Horizon and Locality:—It occurs abundantly in the Cedar Valley limestone, a few feet above the Acervularia davidsoni coral reef, about two miles east of Andalusia, in Rock Island County, Illinois.

CRANAENA SUBOVATA N. SP.

Plate II, Figures 9 and 10.

Description:—Shell subovate to subtriangular in outline, longer than wide, the greatest width anterior to the mid-length, the postero-lateral margins nearly straight, converging to the beak at an angle of about 75 degrees; antero-lateral margins rather strongly and regularly rounded, front margin truncate or nearly straight. The dimensions of a shell of about average size are: Length of ventral pedicle valve 17 mm.; of dorsal valve, 14.5 mm., greatest width 14 mm., convexity 9.5 mm.

Surface of ventral valve arched along the meridian line from beak to front, the greatest convexity slightly posterior to the middle where a faint depression appears, and increases in prominence toward the anterior margin where it forms a broad, shallow, poorly defined mesial sinus. In the posterior part of the shell the transverse curvature is rather strongly convex, being inflected a little toward the cardinal extremities; the curvature is more gentle on the anterior and antero-lateral portions of the valve; the beak is truncated, not strongly incurved, perforated with a moderately large foramen; delthyrium concealed by the beak of the opposite valve.

Dorsal valve about as convex as the ventral, the greatest convexity posterior to the middle, gently arched from the beak to the front margin; the transverse convexity greatest in the posterior portion, the surface curving rather steeply from the median line to the cardinal and lateral margins, and more gently over the anterior and antero-lateral areas; no mesial fold or sinus present; beak pointed, and incurved beneath that of the ventral valve.

The surface of both valves is marked by numerous, well defined concentric lines of growth which vary in number, strength, and distribution in different shells. Shell structure punctate.

Remarks:—This species is more closely related to Cranaena iowensis, described by Calvin from the Cedar Valley limestone in Fayette County, Iowa, than to any other known species. At the type locality in Iowa the shells of Cranaena iowensis are commonly much larger than the most of those belonging to that genus at the Illinois locality from which our specimens were collected. Besides the smaller size the shells of our species are much more triangular in outline, the beaks more attenuate, and the greatest width of the shell much farther anteriorly than in Cranaena iowensis. Associated with Cranaena subovata are shells which in form resemble Cranaena iowensis, and are referred to that species although they are much smaller in size.

Horizon and Locality:—Abundant in the Cedar Valley limestone a few feet above the Acervularia davidsoni coral reef, a short distance west of Andalusia, in Rock Island County.

CRANAENA ELLIPTICA N. SP.

Plate II, Figures 3 and 4.

Description:—Associated with Cranaena subovata, and Cranaena iowensis at the locality last mentioned are shells belonging to the genus Cranaena which differ from either of the above mentioned species in their more elliptical outline, the greatest width being at or posterior to the mid-length; the cardino-lateral margins are straight, and form an angle of about 90 degrees at the beak. An average individual has a length of 15 mm., a width of 14 mm. and a thickness of 10 mm. The surface is marked by numerous, rather fine concentric lines near the front and lateral margins, the anterior margin is truncated, and there is no trace of mesial fold or sinus. These shells have every indication of being fully grown and it is proposed to designate them by the name of Cranaena elliptica.

CRANAENA MAXIMA N. SP.

Plate II, Figure 11.

Among the shells of the species of Cranaena above mentioned there are occasionally found shells that rather closely resemble Cranaena iowensis in outline, but are readily distinguished from any described species of the genus by their very large size. The individual figured measured 40 mm. long, 32 mm. wide, and 15 mm. thick. Such shells may be approximately referred to as Cranaena maxima.

CYPRICARDINIA ORNATA N. SP.

Plate II, Figure 8.

Description:—Shell small, subquadrate to rhombic-ovate in outline; hinge line straight, about half the greatest length of the shell; beaks situated near the anterior margin, directed forward, incurved so that they rise but slightly above the hinge line. The right valve is rather strongly convex; the anterior end short, concave immediately below the beaks, rounding to the basal margin which is straight or very gently convex, and slightly indented a little anterior to the middle. The postero-ventral extremity rounded, above which the posterior margin is obliquely truncate, the surface is most convex in the umbonal region from which it curves rather steeply to the front margin, and more gently towards the hinge line; a shallow depression with poorly defined borders appears near the beak and extends obliquely over the somewhat flattened umbo and on to near the middle of the basal margin. A rather prominent elevation extends from the dorsal or posterior margin of the umbo obliquely backward, with decreasing prominence to the postero-basal extremity of the valve; from this elevation the surface curves rather steeply towards the dorsal margin where the shell is somewhat flattened.

The surface of the valve is marked by prominent, somewhat unequal concentric lines, about 5 mm. apart. The concentric lines, and less distinctly the separating furrows, are crossed by two sets of fine striae, one set of which ap-

pears to radiate from the beak, and the other set crosses the first with a curvature that trends forward and downward from the vicinity of the beak, crossing the first set at an angle somewhat less than 90 degrees.

The left valve was not seen.

The dimensions of the type are: Length 9 mm., height 5 mm., thickness of right valve 3 mm.

Remarks:—This shell is most nearly like Cypricardinia indenta Conrad, from the Hamilton of New York and the East, from which it differs in the smaller size, the greater height in proportion to the length, in the less extended postero-ventral border, the shorter hinge line, and in the peculiar ornamentation of the surface of the shell.

Horizon and Locality:—It occurs in the Cedar Valley stage of the Devonian near Andalusia, in Rock Island County, where it is associated with the species of Cranaena above described.

POTERIOCERAS GIGANTEA N. SP.
Plate III.

Description:—Shell large, subelliptical to ovate in cross-section, somewhat curved throughout, the curvature slight on the concave side, but rather strong on the convex; the greatest curvature is a short distance posterior to the base of the body chamber. The length of the preserved part of the shell is 18 inches, the diameter of the posterior end of the specimen is 2 inches, several of the lower chambers having been lost. The length of the entire shell must have exceeded 20 inches. The shell is somewhat flattened in the direction of the curvature; the largest part of the shell is at the second septum posterior to the body chamber where the greatest diameter is 7 inches and the smallest diameter is nearly 4½ inches. Posterior to this the greatest width decreases rather uniformly at the rate of 2½ inches in a distance of 6 inches. The septa are moderately concave, the average width of the chambers in the larger part of the shell is 3/5 of an inch, and the average width of the posterior 3 inches of the shell is 1/3 of an inch. The body chamber is 4¾ inches long, and has a greatest width of 6¾ inches at the posterior end. Anteriorly the width decreases slightly, being a little more than 5 inches at the place of greatest constriction immediately below the aperture. The aperture is mostly concealed, but it is produced somewhat in the direction of the greatest diameter of the shell. The size and position of the siphuncle are not clearly shown, and the surface markings of the shell are unknown.

Remarks:—This form differs from every other species of the genus known to the writer in its very large size. In shape it somewhat resembles Poterioceras hyatti Whitfield, but the latter is much smaller, and is considerably wider in proportion to its length. The relation of the greatest width and the greatest curvature is also different from that of the species above described.

Formation and Locality:—Occurs in the upper part of the Wapsipinicon limestone, a short distance above the strongly brecciated bed, in the old quarry at Sears, near Rock Island, Illinois.

RHYTICERAS ORNATA N. SP.
Plate IV.

Description:—Shell rather large, regularly expanding, loosely coiled in a little more than two volutions; the greatest diameter is 10½ inches; in the internal cast the distance between the volutions in the middle portion is about 1⅛ inches, but the whorls approach to about ½ inch apart towards the body chamber. The transverse section is subcircular or slightly elliptical, the lateral diameter being a little greater than the dorsi-ventral. The greatest diameter of the whorl (cast) is slightly more than 2½ inches; the original shell was doubtless 3 inches in diameter. The greater part of the body chamber is lacking in our specimen, and the aperture can not be seen. The septa are smooth, their concavity about equalling the depth of the chambers, which is about ⅜ of an inch near the aperture of the shell, and about ¼ inch near the middle,

the depth gradually decreasing from the aperture toward the apex. The position of the siphuncle is not clearly shown in our specimen, but appears to be small, and situated near the ventral side, not enlarged in the chambers between the septa.

The surface is ornamented by a row of prominent nodes or spinous projections about one inch apart along each side, which also appear to mark the position of transverse ridges. Traces of a third row of spines or of a longitudinal ridge appear along the ventral margin of the shell. On the dorsal surface of the outer whorl there are preserved in some places rather prominent longitudinal lines or ridges ¼ to ⅓ inches apart; such longitudinal markings probably covered the entire surface of the shell. Numerous fine lamellose lines of growth, some of which appear to be stronger than others, are also conspicuous on the portions of the shell that are preserved.

Remarks:—In the surface ornamentation this form is readily distinguished from any other known species of Rhyticeras. It differs from Rhyticeras cyclops Hall in the more gradual enlargement of the whorls, the stronger transverse ridges, more prominent nodes along the lateral and ventral margins, and in the finer longitudinal surface markings. From Rhyticeras spinosum Hall it is distinguished by the stronger longitudinal ornamentation, and less rapid expansion of the anterior part of the shell.

Formation and Locality:—This species occurs in the upper part of the Wapsipinicon limestone where it is associated with Gypidula comis, Poterioceras gigantea and Rhyticeras barrisi, near the village of Sears, in Rock Island County, Illinois.

EXPLANATION OF PLATES

PLATE I.

Figures 1 and 2. Diplophyllum? major n. sp. Transverse section of two corallites magnified a little more than two times; and view of a fragment of corallum, natural size.

Figures 3 and 4. Zaphrentis putilla n. sp. Longitudinal view showing septal ridges; and transverse section of a corallite. Both one and one-half times natural size.

PLATE II.

Figures 1 and 2. Rhipidomella minima n. sp. Ventral and dorsal views of the type specimen. A little more than twice natural size.

Figures 3 and 4. Cranaena elliptica n. sp. Dorsal and ventral views of the type; magnified about two times the natural size.

Figures 5, 6 and 7. Pugnoides subovata n. sp. Ventral, dorsal and front views of a typical specimen. Twice natural size.

Figure 8. Cypricardinia ornata n. sp. View of the right valve of a nearly entire specimen; enlarged a little more than two times.

Figures 9 and 10. Cranaena subovata n. sp. Ventral and dorsal views of the type specimen. Enlarged two times.

Figure 11. Cranaena maxima n. sp. Dorsal view of a typical specimen. About twice natural size.

PLATE III.

Figure 1. Poterioceras gigantea n. sp. Longitudinal view of the type specimen. A little less than one-half natural size.

PLATE IV.

Figure 1. Rhyticeras ornata n. sp. View of one side of an exfoliated specimen. About one-half natural size.

WORK OF THE ILLINOIS STATE GEOLOGICAL SURVEY

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Topographic mapping in Illinois was begun in 1887 by the U. S. Geological Survey. In 1905 a co-operative agreement was entered into by the U. S. Geological Survey and the State of Illinois, according to which each party was to make an equal annual allotment. From that time up to the present a total of from $16,000 to $30,000 has been spent each year in carrying this work forward. The State determines the areas and order or progress of the work, whereas the Federal Survey with its corps of trained engineers does the field work, and the maps are engraved and printed at Washington.

The present rate would necessitate about 35 years to complete our own State work as well as that of the United States. Recent detailed study of this situation has shown the need for greater expedition of the work, and a recommendation has been made to speed up the rate so as to complete it in about 12 or 13 years. Such a program calls for an annual appropriation by Illinois of $35,000.00, to be met by a like amount from the Federal Survey. While this may appear a large amount, the urgent need of the maps can be appreciated from such considerations as the following:

1. Public Utilities.

Available topographic maps made by the U. S. Geological Survey saved the City of New York hundreds of thousands of dollars and years of time in extending its water supply. This need was emphasized by the time and work required where the maps were lacking or obsolete.

After expending $10,000 in examining sources of water supply for Waterbury, Conn., the city engineer had access to topographic maps of the area and from an inspection of these was enabled to develop a better supply which is used at present.

2. Industrial Development.

The value of a topographic map of one quadrangle in Washington was estimated to be worth more than its en-

tire cost to one company alone. This permits efficient exploitation and development of the resources of an area and should mean increased economy for the general public.

3. Highway Construction.

Federal and State governments are spending hundreds of millions of dollars each year in road building and these projects call for a mass of detailed information. Where accurate detailed topographic maps are not available, costly preliminary surveys must be executed.

A member of the Wisconsin State Highway Commission estimated that a complete topographic map of Wisconsin would be worth more than its entire cost just for the road building program. The Association of State Highway officials considers that the saving in highway funds alone would be greater than the cost of making these Topographic maps.

The chief engineer of the Iowa State Highway Commission estimated that 50% of 6000 miles of a primary road system might have to be modified to secure proper grades and alignment because no topographic survey was available when the roads were first planned. In our own State, road building may average as high as $35,000 or $40,000 per mile. Hence our increased annual appropriation represents the average cost of only one mile of highway construction.

Maryland has a complete topographic map of the State, and the chief engineer of the State Roads Commission estimates the saving on road work to exceed the entire map cost.

For initial and maintenance use of State Highways, the value of such maps has been estimated to be worth at least $250.00 per mile. This figure applied to Illinois maps makes the first cost appear insignificant.

4. Transportation Needs.

Transportation problems involve the construction and use of railroads, highways and waterways, and are greatly facilitated by topographic maps. If adequate topographic

maps are available, new construction and improvement of existing routes can be accomplished without preliminary surveys.

One resident railway engineer estimated such saving in a short piece of railway work in Ohio at $85,000.00. The map cost was $4,000.00. Another railway engineer considers that hundreds of thousands of dollars are annually spent and much of it absolutely lost through lack of having the country mapped. This loss rests upon the public in capitalized costs.

5. Use of Water Resources.

A rational utilization of water for irrigation, municipal supply and power development, depends upon a knowledge of total annual yield of the stream which is to serve as the source of supply, the daily variations in flow, and the practicability of constructing reservoirs of sufficient capacity to store the water until needed for use. Many projects involve the construction of canals, channels or reservoirs. All these problems necessitate a broad comprehensive knowledge of the topography of the catchment basin. Other problems call for a map of the topography of dam sites, reservoir sites, canal lines, and the configuration of the irrigable lands.

In order to develop intelligently the water-power resources of a state, it is first necessary to know what those resources are. Before a final analysis of such water-power resources can be properly formulated, the greater part of the state should be mapped topographically. As only one-third of Illinois has been mapped, we cannot yet make adequate plans for our own water-power development.

6. Drainage.

In order to dispose properly of surplus water in swampy and flooded regions, it is necessary to know the extent and slope of the land to be drained, the area of the catchment basin yielding water into the drainage system and the location, slope and capacity of the ditches for reclaiming such land. In Illinois there are about 1,150,000 acres subject to overflow, and additional area of the State is subject to betterment through drainage.

7. Agricultural Development.

Maps showing the character of the soil and the configuration of the ground indicate to the settler the desirability or undesirability of any particular piece of land for farming, and so assist him in its proper cultivation. Hence soil maps are of increased value where printed on topographic maps.

8. Development of Mineral Resources.

Geological study showing the mineral resources of a region must be preceded by a topographic map of the area on which to plot the field data. Many promising mineral areas in the west now await topographic mapping for their detailed study and development.

9. Utilization of Timber Resources.

The economical examination of timber bodies, the location of logging railways and tramways, the estimation of costs of logging operations, the determination of areas that can be logged from different bases of operation, the selection of lines of communication, lookout points, fire lines, etc., are all dependent upon a knowledge of the topography as well as the forest cover of the region considered. Hence a topographic map is fundamental to the wise administration of forested areas, decreasing the cost and materially increasing the efficiency of forest management.

10. Utilization of Grazing Resources.

Efficient administration of grazing lands requires mapping of the topography and vegetative cover, in order that the kind of stock and number of animals that can be carried may be determined, and that appropriate seasonal use of the range may be planned. Such maps are invaluable aids in range management.

11. Educational Uses.

In the study of physical geography, topographic maps of the U. S. Geological Survey are of widely recognized value. To the trained reader such maps give a great variety of information such as suggestions of climate, character of underlying rock, industries of an area and geologic history.

12. Popular Uses.

Motor users, both for business and pleasure, find the maps of great value because of the accurate record of roads, grades and distance between distant points.

13. Statistical Uses.

Such maps are of wide use and recognized value as base maps for graphic representation of facts relating to population, industry, products, etc.

14. National Defense.

Such defense can be efficiently planned only where accurate topographic maps are available. The transfer, disposition and maintenance of a military organization require a detailed knowledge of topography. For offensive and defensive preparation such maps are absolutely indispensable. As a measure of preparedness, such maps justify all possible haste for their completion.

About one-third of Illinois has been topographically mapped, but some revision of the older maps has been found necessary, so that 30% of the State now has good maps available. As fast as the quadrangles of a county are completed, the State issues a topographic map of that County. Maps of eight counties are now available (Clinton, Gallatin, Hardin, Lawrence, McDonough, Monroe, Randolph and St. Clair). As soon as three quadrangles and parts of five more are completed, the State can issue topographic maps of Alexander, Jackson, Johnson, Massac, Pope, Pulaski, Saline, Union and Williamson Counties.

As numerous drainage projects and many miles of highways will be planned and constructed in the next decade, the wisdom of hastening the completion of our State Topographic map is obvious. Lack of it means not only delay in carrying forward certain improvements, but additional cost for development and construction work preceding their completion, and the people of the State pay for this extra cost in higher utility and service charges. Thus our State Legislature, by making an appropriation of $70,000 for the next biennium for this work, will assist greatly in the State's development and will save our people many dollars in unnecessary construction costs and capitalized charges.

The present biennium has seen the completion of a drainage survey of the State under the supervision of the State Geological Survey. The information thus collected and published as bulletin 42 presents a remarkable picture of agricultural opportunity in this State. More than 1,100,000 acres of bottom lands are subject to overflow and in consequence, has merely a nominal value at present. Yet these same lands, where reclaimed by feasible drainage projects, will add millions of dollars to the wealth of the State.

Although Illinois is considered primarily an agricultural state, the annual mineral production ranges well up into millions of dollars. Coal, clay, cement, oil and building stone are a few of the raw products present here in abundance and their economical and efficient exploitation is due in large part to the scientific work conducted by the Illinois State Geological Survey.

THE GLACIAL HISTORY OF THE SANGAMON RIVER VALLEY AT DECATUR AND ITS BEARING ON THE RESERVOIR PROJECT

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Glacial Geology seems so far removed from applied science that one might pass the judgment that it has no utilitarian end; that its chief justification lies in its contributions to pure geology, in helping to reveal to mankind that history of his surroundings. Without doubt one of its chief functions is that of supporting pure science, but one needs only to come in touch with the soil specialist, or the tunnel engineering expert, or the hydrographic engineer, or the materials-survey man to be reminded that in all states north of the glacial drift boundary and in glaciated mountains, Glacial Geology has a very definite bearing on certain industrial projects.

Experience has taught the engineer that the construction of a dam across any valley in the glaciated area must be undertaken with caution. The materials beneath the dam must have sufficient bearing power to support the weight of the dam, and must be tight enough to prevent seepage from beneath. The materials at the ends of the dam and in the natural walls of the reservoir must also be impervious to excessive leakage. In order to pass judgment upon the character of glacial material for these purposes the engineer desires to know the properties of these materials, the possible relationship of the porous to the nonporous, and the characteristics of the drift-sheets at his particular locality. Obviously this involves the principles of glacial and aqueo-glacial sedimentation and in some cases the differentiation of drift-sheets.

THE DECATUR DAM

At Decatur, Illinois, a dam is being constructed across the Sangamon River Valley, which will be 15 feet high above the present river level and which will impound the waters upstream for a distance of about 12 miles and create a reservoir over 3,900 acres of territory. The base of the

dam will be 72 feet wide including a concrete apron but exclusive of a 30-foot clay apron on the upstream side. It will extend to a depth of 3½ feet below the lowest part of the bed of the river, and cut-off sheeting will be driven to a maximum depth of 30 feet below the base of the concrete portion of the dam. The ends of the dam will be earth instead of concrete and cut-off sheeting will reach to somewhat less depth than in the central portion of the valley.

Before undertaking the construction, the engineering company made a series of test-holes across the valley to ascertain the character and thickness of materials. Samples were collected, but due to the fact that these were from a "churn-drill," which separated the coarse from the fine, nothing but sand and gravel was reported, whereas till was found later to be involved. Upon these data the specifications were drawn and the work was undertaken. In driving the cut-off sheeting, a hard-pan was encountered at varying depths which was practically impossible to penetrate. It, therefore, became desirable to know the nature of this hard pan, its thickness, and relations to underlying materials. A geological examination was consequently requested.

GEOLOGICAL PHENOMENA

Decatur is situated on the eastern border of the Shelbyville Moraine, which has a width here of several miles. The altitude of the moraine at the river bluff is said to be about 650 feet above sea-level. The valley here is about 50 feet deep, but farther west in the moraine it is 75 feet or more. West of the moraine it is scarcely over 50 feet, but is much wider than in the moraine. This seems to indicate that the portion beyond the moraine is pre-Wisconsin in age, and this is supported by some of the tributaries which are beheaded by the Wisconsin deposits.[1] The incision of this part of the valley in Illinoian drift would therefore make its age post-Illinoian and pre-Wisconsin.

Leverett states that the average thickness of the Shelbyville drift is 100 feet, an estimate based on the relief of

1. Leverett, Frank: The Illinois Glacial Lobe, U. S. Geol. Surv., Mono. 38, 1899, p. 518.

THIS CHART WILL BE THE
SECOND CHART APPEARING
AT THE END OF THIS FILM

the moraine above. If this were the case, it would seem that the valley through the moraine must have been completely filled, but this figure seems excessive, and there are reasons for believing that the valley was not buried.

After the hard-pan was discovered, a new series of well-borings was made, this time in such a way that samples of the material as it actually occurs were taken at desired intervals. Three well-borings and four test-pits were put down on the north side and eleven well-borings and four test-pits on the south side. These revealed the following strata, as shown in Figure 1.

GENERALIZED SECTION OF THE STRATA IN THE SANGAMON RIVER VALLEY NEAR DECATUR, AS DETERMINED FROM BORINGS AND TEST PITS.

		Thickness Feet
3.	Soil and flood-plain alluvium, a brownish sandy silt toward the valley walls, becoming darker near the stream.....	5-10
2.	Sand and gravel, distinctly sandy, thins out toward the valley walls, thickens toward the stream, maximum thickness.....	35
1.	Till, called "hardpan" by the drillers, dense, compact clay with scattered pebbles and bowlders, difficult to penetrate, contains a few thin layers of sand, of which the thickest, 12 feet, is on the south side, maximum thickness penetrated.....	54

An examination was made of the glacial till exposed in the new sewage ditch along the valley farther west in the moraine. The till here contained considerable masses and thick lenses of gravel and sand, some of which show marked contortion by ice movement. One of these lenses was about 200 yards long. If such a lens were to occur in the till beneath the dam, it might permit excess leakage. But the till in the sewage ditch seems quite clearly to belong to the Shelbyville moraine, while the till beneath the dam appears to be Illinoian, of the ground moraine type. If so, their difference in origin would appear to have a direct bearing on the question of dam construction. The reasons for this discrimination will now be considered.

SUPERPOSED DRIFT-SHEETS IN THE NORTH VALLEY WALL.

In the north valley wall at the dam site, the construction company has opened a clay pit for obtaining clay filling. An unusual section is there exposed, having the following sequence:

3. Wisconsin till, overlain by "wash" from the slopes and capped with soil; upper part, including "wash", is leached 3 to 4½ feet, the underlying 0 to 2½ feet being calcareous; total exposed .....4½ to 7 feet
2. Old soil .....6-8 inches
1. Illinoian till, gray below the soil, brownish below, leached 3 to 4 feet, calcareous below, compact; total exposed.....6 feet

A short distance west, the ditch for the cut-off sheeting, which transects the valley slope, shows the same sequence, but here the trend of the exposure is at right angles to the valley and shows the relation of the pre-Wisconsin surface to the valley. . The contact dips steeply toward the valley in conformity with the valley wall. Thus it appears that the present north valley wall is almost essentially that of pre-Wisconsin times. This is in agreement with the belief that the thickness of the Wisconsin drift was not sufficient, at least along the line of the Sangamon Valley, to fill the valley. The failure of the hard-pan to rise as much on the south side of the valley as on the north is taken to indicate that the valley was wider in pre-Wisconsin time than at present. This is in harmony with the characteristics of the valley outside of the moraine.

The hard-pan beneath the dam is at just such a level as one would expect if the slope of the surface of the Illinoian drift were projected into the valley. The sand deposit of the valley, at this point, is, therefore, believed to rest directly on Illinoian drift, with little or no Wisconsin drift intervening. The "hard-pan" is characteristic of the Illinoian. Leverett has recorded the general observation of well drillers that the passage from Wisconsin to Illinoian drift is marked by a difference in hardness, "the earlier drift being partially cemented and much more difficult to penetrate than the overlying later drift sheet."[1]

1. Idem, p. 199.

SAND AND GRAVEL FILLING OF THE SANGAMON VALLEY.

The sand and gravel filling in the Sangamon Valley has already been noted. No distinct terrace is shown at the dam site, but on the south side of the valley, slightly above the present flood-plain, gravel underlies alluvium and "wash" from the south slope. All of this gravel filling is believed to be correlative with the remnants of gravel terraces which occur both upstream and down, and which appear to have been deposited as a valley train from the ice during the building of the Cerro Gordo moraine.

SUMMARY OF THE HISTORY OF THE SANGAMON VALLEY AT DECATUR

Restricting our discussion to that part of the Sangamon Valley at Decatur, it may be stated that present data indicate that it dates back to the Sangamon interglacial epoch, and probably to the close of the Illinoian glacial epoch. Upon the melting of the Illinoian ice, the area was a flattish ground moraine, and during the Sangamon interval, the drainage cut a relatively broad, shallow valley at Decatur commensurate with that portion of the valley beyond the Shelbyville moraine. Contemporaneous with the valley cutting, the Illinoian till was leached and oxidized and soil was developed, extending down some parts of the valley slope.

The change of climate from warm to glacial resulted in the Wisconsin ice invasion which reached its extreme limit a few miles west of Decatur. For a time the ice edge remained within the zone of the Shelbyville moraine and radically changed the contour of the Illinoian surface by depositing morainic materials. Some of them were deposited directly from the ice, some by the glacial waters. Readvances of the ice contorted the gravels and buried them with till. As a result, the moraine was formed of both till and sand and gravel with complex relations.

The amount of drift deposited across the valley was not enough to fill and eradicate the valley. The concentration of the glacial waters doubtless helped to keep the valley free. Consequently enough of a depression was left to serve as a drainage line upon the retreat of the ice-front. In this inherited depression, after some modification by the

glacial waters, a valley train was deposited, which may have come from the ice during the building of the Cerro Gordo moraine. Since the disappearance of the ice, the sand and gravel fill has been partly eroded away and a flood-plain, 150 to 200 feet wide, has been developed on both sides of the stream.

RELATION TO THE RESERVOIR PROJECT

According to the foregoing interpretation the "hard-pan," or glacial till, which is to receive the cut-off sheeting, is drift of the Illinoian ground moraine and not drift of the Wisconsin terminal moraine. Since the drift of the Illinoian ground moraine was deposited chiefly beneath the ice, rather than at its terminus, it is a typical clay-till. It is, therefore, unlikely that it contains lenses of sand and gravel thick enough to afford excessive sub-surface leakage as would likely be the case if the drift were a part of the Shelbyville moraine.

THE EFFECTS OF FAULTS AND DYKES IN THE SALINE COUNTY COAL FIELD

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(*Synopsis Only.*)

At Carbondale this paper was accompanied by a large map of Saline County showing the coal fields, existing workings, and the faults and dykes known when Co-Operative Mining Bulletin No. 19, Coal Resources of District V., was issued from Urbana. Additional faults and dykes, discovered or indicated in the workings and drillings since that time, were added. The effects of these dykes and faults in working the field in the past and the difficulties to be overcome in future operations were discussed. The value of published geological facts concerning such features of a mining field was pointed out. It was shown that the data collected and chiefly published by the Department of Geology of the University of Illinois, working with the United States Bureau of Mines, is of great value in determining the location of new mines and especially of shafts.

Since the main lines of faulting are now pretty well known in this field, future operations will be carried on without the losses formerly sustained in encountering unsuspected dykes and faults. Since dykes are more local, their size and character and, in fact, their location cannot be foretold except by actual boring. The largest dyke so far found in Saline county was discovered in sinking a shaft a short distance from a drill hole which showed no evidence of such a geological feature. The work was made much more expensive due to the hardness and extent of the igneous rock encountered.

Since the general trend of the large faults is now fairly well known, as they are found in actual workings or shown by drill hole records, it is not probable that the mistake of sinking a shaft near a 150 foot fault will be repeated.

DISCUSSION BY H. E. CULVER OF CLARENCE BONNELL'S PAPER "THE EFFECTS OF FAULTS AND DYKES IN THE SALINE COUNTY COAL FIELD."

"The presence and position of the dykes on the property of No. 5 of the Saline Co. Coal Co. has been suggested as a determining factor on the sulphur content of No. 5 seam. It is therefore desirable that the exact position and character of the dykes, their relation to No. 5 and No. 6 seams and the character of the seams be carefully noted in order that the problem may be settled."

STRATIGRAPHY OF THE SOUTHERN HALF OF THE LA SALLE ANTICLINE[1]

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GENERAL RELATIONS

The La Salle anticline is an anticlinal fold which runs a little west of north and a little east of south through eastern Illinois. It appears in outcrop in La Salle County and extends without outcrop evidence to Lawrence County, Illinois; from that place it is not as well understood. The Galena-Trenton limestone outcrops at La Salle, and from that place to Lawrence County, Illinois, underlies a zone of anticlinal folding over 200 miles long. There is no rock section outcropping from which to make any direct studies on the conditions which underline the southern part of the La Salle anticline, as practically all the area is covered by from 50 to 200 feet of glacial drift. The western limb of the anticline has a very steep dip, while the eastern is usually not so steep, and in places a double fold exists. Practically all the oil production in Illinois has been from structures associated with this La Salle anticline in Lawrence, Crawford, Clark, and Cumberland counties.

PURPOSE

The purpose of this paper is to establish, if possible, from data obtained by the study of well logs and samples, facts bearing on the ages of the folding along the La Salle anticlinal zone; also to apply the age of folding to a practical consideration of oil accumulation, and to the interpretation of folds in the lower formations from shallow test holes. It is realized that well log interpretation can not give unquestionable results, but it is hoped that in this area where direct study of the rock section is impossible some facts obtained from well logs may be logically linked with paleontological interpretations made elsewhere for the seas in which the different formations were deposited. The area discussed is approximately 90 miles in length by 20 miles in width and consists of parts of Douglas, Edgar, Coles, Clark, Cumberland, Jasper, Crawford, Richland, and Lawrence counties.

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1. This paper is preliminary to a more detailed discussion of the subject in a forthcoming bulletin of the Illinois State Geological Survey. Points that have been considered as proof of these conclusions will be detailed at that time.

PITCH OF ANTICLINE

The formations along the strike of the zone show locally many variations. They deepen in general from La Salle County southward. In places reduced pitch, flattening, and reversal of pitch exist. From south Douglas County to south Lawrence County (80 miles) the net pitch would average 35 feet per mile.

ROCK SECTION

Ordovician,
"Trenton" (Kimmswick?),
Maquoketa or Richmond,
Silurian,
Devonian,
Lower Mississippian,
Chester,
Pennsylvanian.

"TRENTON"

The Ordovician limestone, the "Trenton" of the oil-well driller, which corresponds approximately to the Kimmswick and Galena, occurs under this area at varying depths to the top, from 500 feet to 3,700 feet below sea level, depending on the locations with respect to the dip of the flanks and pitch of the axis of the fold. There are not sufficient holes going through the Trenton to give any information as to variation in its thickness. The upper 200 feet is composed of limestone. The oil production comes from limestone. The highest magnesium carbonate content determining from two samples of the oil-producing "sand" was 3 per cent.

MAQUOKETA

Over this whole area, the Maquoketa usually consists of three members: a basal member of shale varying from 110 to 130 feet in thickness, a middle member of limestone from 40 to 60 feet in thickness, and a top member of shale from 90 to 100 feet in thickness. The total thickness of the so-called Maquoketa is from 230 to 270 feet. The top of the formation is reached at elevations varying from 250 feet to 3,400 feet below sea level. North of the

zone under discussion, for example in Kankakee County, it is reached at about 500 feet above sea level where it consists of the same three members.

SILURIAN AND DEVONIAN LIMESTONE

The State Geological Survey has been gathering samples, a study of which may give some good basis for differentiating the Silurian from the Devonian beds. It is usual for the Silurian to be dolomitic and the Devonian to be calcareous. For the purpose of this paper the two systems are considered together. The total thickness over the area varies from 800 feet to 1,050 feet. Changes in elevation of the top are from 300 feet above sea level to 2,600 feet below sea level.

SO-CALLED UPPER DEVONIAN SHALE

This shale varies in thickness from 100 to 175 feet over the whole area. Tests have shown a variation in thickness of 25 feet in half a mile. The overlying beds being apparently regular, the loss in thickness of the shale suggests the possibility of an underlying irregular limestone surface due to erosion. The maximum change in thickness occurs between the extreme north and south parts of area. East and west off the crest of the fold the shale sometimes thickens 25 feet. The top of the shale is found at elevations varying from 400 feet above sea level to 2,500 feet below.

LOWER MISSISSIPPIAN

On account of a large unconformity at the top and the rise of the anticline to the north, the Lower Mississippian varies from very small thickness up to a maximum of 1,300 feet. The base of this formation occurs from elevations of 400 feet above sea level to 2,500 feet below sea level.

CHESTER

The base of the Chester formation is found from 100 feet to 1,600 feet below sea level. The Chester varies from practically no thickness to a thickness of over 700 feet.

PENNSYLVANIAN

The base of the Pennsylvanian is found from 500 feet above sea level to 800 feet below sea level. The Pennsylvanian varies from practically no thickness to a thickness of 1,400 feet.

FOLDING

TRENTON TIME

The finding of apparently typical Kimmswick limestone in Clark County in the supposed area of the Galena sea, will introduce a question as to the amount of folding that took place during or prior to this time along the zone of the present LaSalle anticline which was considered the barrier between the Galena and the Kimmswick seas.

MAQUOKETA TIME

The fact that three members of the Maquoketa, alternately shale, limestone, and shale, were deposited over most of this area and occur today at elevations varying over 3,000 feet, with only a total maximum change of 50 feet in thickness, shows that the formation must have been deposited over the whole area under very similar conditions relative to the source of supply, and on a practically flat surface.

If folding occurred prior to or during Trenton time erosion probably removed all traces of any "Trenton relief" before the Maquoketa was deposited in the zone of the present La Salle anticline. Otherwise the Maquoketa would not be as consistent in thickness and character as it is.

SILURIAN AND DEVONIAN TIME

These two geological ages, represented by a total thickness of approximately 1,100 feet, must have seen tremendous time intervals of erosion and deposition. Probably earth movements and possibly folding took place. However, whatever the conditions may have been, they were apparently similar over this whole area. The fact that, in Parker Township, Clark County, the fold in the "Trenton" has been shown to be parallel with the top of the Devonian formation and similar to the fold in the Mississippian formations suggests that folding in Silurian or Devonian times in the anticlinal zone was very improbable. Undoubtedly the thickness of individual Silurian and Devonian members may vary over this area.

As there are no signs from drill records that any considerable erosion into the upper bed of the so-called Maquoketa has taken place, continued submergence probably fol-

lowed Maquoketa time. (Contact between the upper Maquoketa shale and the overlying limestone has been taken as the contact of the Ordovician and the Silurian. This contact seems very regular and if it represents the division between the Silurian and the Ordovician, the uncomformity must have been slight.) The total thickness of the Silurian and Devonian limestone phase varies about 250 feet, being 800 feet thick to the north in Douglas County, and 1,050 feet south in Crawford County. It also thickens in Clark County to about 950 feet off the arch of the fold. The tests north in Coles and Douglas Counties prove unconformable relations with the overlying chocolate shale, showing Onondaga limestone immediately below the shale at one location and Hamilton as a top formation elsewhere. As erosion is proven to the north, undoubtedly part of the increase of 100 feet found locally and 250 feet found regionally must have been caused by erosion. Were this whole difference due to a pre-existing fold, it would be but slight, and since it is in part due to erosion, any folding which there may have been must have been insignificant. The fact that there was only a 250-foot decrease in the entire area from Crawford County to Douglas County with present variations of 3,000 feet in elevation proves that the land surface must have been practically level at the close of that part of Devonian time, or that any folding that took place caused practically negligible effects both north and south, and east and west.

LATER DEVONIAN TIME

The so-called Devonian or chocolate shale varies from 100 to 175 feet in thickness. The maximum difference in thickness occurs between the north and south parts of the area. Locally, in places off the structure, the shale increased 25 to 30 feet in thickness. At present the top of the shale occurs at elevations varying up to 3,000 feet, with a maximum variation in thickness of 75 feet. At the close of this time this whole area must have been practically flat.

LOWER MISSISSIPPIAN TIME

The Lower Mississippian is about 1,300 feet thick in Lawrence County, where it is capped by the Chester for-

mation, which completely wedges out as the anticline rises to the north. In Lawrence County the lower Mississippian is all limestone; in central Clark County the basal member is 250 feet of sandy shale, overlain by 200 feet of sandy lime; in southern Coles County the Lower Mississippian has less lime and more shaly sandstone; in northern Coles County the basal 500 feet is all shaly sandstone without lime. East and west off the structure, the limestone members appear over this basal sandy phase. This increasing sandy character of the beds as one goes north is undoubtedly due to the closer approach of the "source of supply," which lay north or northeast during Mississippian times.

CHESTER TIME

The Chester lies unconformably on the Lower Mississippian.

In Lawrence County the Chester is thickest and it becomes progressively thinner to the north along the anticline until it disappears in southern Clark County; and from any given point on the crest of the fold the Chester thickens both to the east and to the west. Since the Chester includes beds of Lower Chester age even where it is thin, and since the same sand horizons as are found where it is thicker seem to be present in the Chester where it is comparatively thin, it may be inferred that the northward thinning of the Chester and especially its thinning over the crest of the fold are due to erosion subsequent to the deposition of a more or less complete section of Chester over the whole area. In agreement with such an inference, the Chester contact with the overlying Pottsville shows a very marked unconformity which indicates that the erosion interval in places must have been great. Of course, a part of the northward thinning may be credited to the fact that the Chester shoreline possibly lay to the north, but it can not all be explained in this way.

The fact, previously mentioned, that Lower Chester beds persist into the areas where the Chester is thin, shows that no decided diastrophic movements took place in this area until after Lower Chester times. However, the repeated alternation of sandstones, shales, and limestones through-

out the Chester, indicates gentle earth movements that may be considered introductory to the big earth movements which took place at or near the close of Chester time. These big earth movements are believed to have been the first to produce any structure in the southern half of the LaSalle anticlinal zone of a magnitude comparable to that of the present day.

PENNSYLVANIAN TIME

The Pennsylvanian is found along the La Salle anticline resting uncomformably on rocks of all geological ages from Ordovician to Chester. To the north it is very thin, and there is no doubt that the northern part of the anticlinal zone and even the crest of the fold farther south must have been outside the area of deposition during part or all of Pottsville time.

The base of the Pennsylvanian varies in elevation from 500 feet above sea level to 1,000 feet below sea level. Its thickness varies from a few feet up to 1,400 feet. The hiatus represented by the uncomformity at the base of the Pennsylvanian is very great, as in the extreme instance all beds that might intervene between the Ordovician and Pennsylvanian are missing. Above the Pottsville the amount of Carbondale and McLeansboro deposited varies slightly in most cases. Wherever these formations thicken east and west off the anticlinal crest, the thickening is chiefly due to the coming in of lower beds rather than to the thickening of upper members. This evidently indicates continuance of movement after the beginning of and during early Pennsylvanian time, and is responsible for a greater accentuation of folding in rocks older than the Pennsylvanian than in the Pennsylvanian rocks themselves. Probably the difference in elevation caused by late and post-Pennsylvanian folding is in places as much as 500 feet, as shown by present elevations of late Pennsylvanian beds. This latest folding is itself capable of producing in the different beds sufficient "structure" to account for the known oil pools on minor structures along the La Salle anticline.

It seems probable then that in the southern half of the La Salle anticline at least, the arch did not exist except in a very minor way until late Chester or more probably Potts-

ville time. This folding may have brought the Chester age to a close, destroying the Chester sea.

The significance of these points is that any structure which exists in the Mississippian will be reflected through to the Ordovician horizons in spite of any unconformities which exist, and that the major features of the structure in the Pennsylvanian rocks will be closely associated with more accentuated structure in all horizons below the Pennsylvanian. If shallow key horizons in the Pennsylvanian or Mississippian can be relied upon, for interpreting the structure of deeper horizons, then prospecting by such a method is practicable.

CONCLUSIONS

1. The southern part of the La Salle anticline in anything like its present magnitude did not exist before the close of Chester time.

2. The big movement which caused the main, structural features of the La Salle anticline took place immediately prior to and during Pottsville time.

3. The folding shown by Mississippian beds will be reflected in similar degree in the underlying strata.

4. The folding exhibited by Pennsylvanian strata will be reflected in more accentuated form in all the underlying strata.

THE RELATION OF THE SECONDARY SCHOOL TEACHER TO THE RESEARCH WORKER

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Obviously the secondary school teacher is dependent on the research worker for new developments in his subject. This fact is so evident that it needs hardly to be mentioned. A person who finds secondary school work worth while at all discovers that his interest is first of all in the young people with whom he deals, not so much in his subject. He is teaching boys and girls, not Latin, or Mathematics, or English, or Geography. If he would, he has little time for investigation. In the large secondary schools, a teacher meets from one hundred to two hundred fifty pupils in his classes every day. Not many teachers meet so few as one hundred pupils. So his dependence on the research worker for new light on his subject is very real.

The research worker is the instructor in the Normal School, College, or University where the secondary school teacher is prepared for his work. The point of view in these classes is so often that of the specialist, that the readjustment of the young person who goes into secondary school teaching is often difficult and long. His college instructors were specialists whose interests were in the subject, and the young teacher carries into his new work something of the same attitude, only to find that a readjustment is necessary if he is to succeed. We hear a great deal of the poor preparation of high school teachers and their lack of training in their particular subjects. There is undoubtedly cause for this criticism. But the secondary school teacher may be too much of a specialist. Often much serious difficulty occurs because the methods and subject matter of the college are carried into the secondary school where they ought not to be. Both the college instructor and the student preparing for teaching must realize that the interest of the secondary school teacher is in his pupils, and the choice of subject matter and methods depends upon the pupils' needs and interests. The object is not to give them a logical, comprehensive view of the subject, but to

give them facts that they will use, and to train them in solving problems so that they may each take a useful place in society. College and university training without this point of view does not develop the best teachers for the secondary school.

We in the high school are somewhat dependent upon the research workers for our text books. High school teachers have had the courage to tax their time and strength for the writing of text books. When they do this, some of their university and college friends wonder if their knowledge of their subject is sufficient to warrant the undertaking, forgetting that what the high school pupil needs is a book so simple that he can read and understand it, dealing with phases of the subject which touch life as he knows it, and giving him only the most obvious facts which he will need later on. He does not need a carefully compiled, logically arranged treatise on the subject.

The work of investigators in departments of education is becoming increasingly valuable to teachers of all grades. The intelligence tests which are being worked out are of great assistance in classification of pupils. In the subjects presented in the secondary schools standardized tests can not be worked out in such detail and definiteness as has been done in silent reading, arithmetic, writing, spelling. There is a certain definite minimum in arithmetic which the experience of civilized man has made desirable to be acquired by every one. We are all agreed that ability to read with understanding, to write legibly, to spell words in common use, should be acquired by every citizen. But who can say in such definite detail exactly what should be the possession of those who study History, Geography, Botany, Zoology, Chemistry? Time was when people thought it desirable to put into spelling books unusual, peculiar, little used words. Now we have careful studies made of the words most commonly used by children in their own activities; studies of words used most commonly in newspaper and magazine articles; of those used by standard authors. These lists are the basis of work in spelling. Those who are writing text books to be used in the secondary schools need to be in close touch with the departments

of education in their institutions, in order that they may profit by such studies. An investigation of the geographical facts most often referred to in non-geographical articles in newspapers and magazines, in the routine of the business office, in classes studying Botany, Zoology, History, would give an excellent basis for the material to be presented in a high school geography text book.

Such subjects as Geography are useful not only for their information content but for the power they develop in making judgments, and solving problems; and text books should be so written as to develop this power. The research worker who undertakes to write a text book for use in the secondary school, but who does not know the needs of the secondary school pupils, and who is not in touch with the work of some department of education, is making a great mistake, and is losing an opportunity to give us a workable, helpful book.

I assume that I am talking to persons who are mostly research workers. We in the secondary school acknowledge our dependence on you, a very real dependence. But when you are preparing young men and women to join our ranks, and when you are writing text books which you hope we will use, please remember that our interest must be primarily in the teaching of the child, not in the subject.

THE GEOGRAPHIC VALUE OF THE GALLATIN COUNTY SALINE.

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The most important geographic factors are not necessarily the largest nor the best known. Neither are they always the ones which have been operative over the longest periods of time. It is the character of man's response and extent to which it affects the course of his development that determine their value.

Man responds most readily and most unmistakably to those factors which supply his actual daily needs. If, in addition, he derives from those factors, either the incentive or the means for developing new lines of activity or of thought, their influence may become far-reaching in its effect. An apparently insignificant factor may thus be of large geographic value.

Such is the case with the Gallatin County or Wabash Saline. Situated in the midst of a swampy area, inaccessible through considerable portions of the year, and today all but unknown to many of the residents of that part of the state, it, nevertheless, was one of the most potent factors in the early development of southern Illinois.

Its first value lay in the fact that it supplied a vital need. In the case of civilized man, the need for salt is so imperative that his use for the substance is regarded as one index of his position in the cultural scale. This is because his food—largely vegetable in character and rich in potassium salts—so tends to reduce the salt content of his blood, that in order to maintain its normal amount, the addition of free salt is necessary. Meat—especially raw or half-cooked meat—does not make the same demand upon the salt content as do vegetables, and for that reason, savages living on an almost exclusively flesh diet do not need salt nor care for it.

Because salt supplies a direct need, settlement has everywhere followed closely upon the discovery of salt sources. At a time when transportation facilities were poor, when there were no railroads or steamboats, and when the in-

terior of the country was largely an uncharted wilderness, it was of great importance to be situated near to a supply of salt. To be freed from the necessity of making long trips for it meant more than one can realize today. As a result, all through the West there was a decided tendency toward the concentration of settlement at or near the salines.

In the case of the Wabash Saline, but a short period of time elapsed between its cession to the United States by Indian treaty in 1803[1] and the formation of a considerable area of settlement in southeastern Illinois. Within a bare year and a half, a sparse colony had formed about it,[2] and the rapid growth in population which followed, and which made possible the early formation of the state, was distinctly related to the Saline. In 1818, when Illinois entered the Union, perhaps one-sixth of the entire population of the southeastern part of the state was concentrated within a few miles of the salt works.[3] This was due not only to the natural drift of population toward the region of supply, but also, and in far greater degree, to the commercial and industrial opportunities which it offered. The first people who came into the territory recognized these possibilities, and before long, in conjunction with the Federal Government which reserved the salt lands[4] and then leased them to individuals,[5] they had developed an industry which not only supplied salt to the inhabitants of Illinois, but furnished considerable amounts for shipment into Indiana, Kentucky, and Tennessee.[6] By 1810, the works were yielding about 150,000 bushels a year,[7] and boats and barges laden with salt were of common occurrence upon the Ohio, Cumberland, and Tennessee rivers. Within a few more

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1. Treaty with Delaware, Shawans, Pottawatomi, Miami and Kickapoo, June 7, 1803. (7 *Statutes at Large*, 74).

2. Reynolds, John, *My Own Times* (Ill. 1855), 47.

3. Estimate from data given in Buck, Solow Justus. *Illinois in 1818* (Chicago, 1918), Chapter III.

4. Sec. 6, Act for Disposal of Land in Ind. Territory, *Annals*, 8th Congress, 1st. sess., App., 1289.

5. Greene, Evarts B., and Alvord, Clarence W. (ed.), *Governor's Letter Books 1818-1834* (Springfield 1909); Edwards, Ninian, *Life and Times of* (Springfield, 1870), and Washburne, E. B. (ed.), *Edwards Papers* (Chicago, 1884) contain much valuable correspondence relative to salt leases.

6. Worthen, A. H., *Geological Survey of Illinois*, VI. (Boston, 1875), 214.

7. Cramer, *The Navigator* (Pittsburg, 1814), 272.

years production had increased to 200,000 bushels,[8] and salt had become a leading basis for the commercial prosperity of southern Illinois.

Shawneetown, situated on the Ohio River 12 miles east of the salt works, owes both its origin and much of its subsequent importance to the salt trade. It was never a large town; the fact that at first individuals could not hold title to their property, because until 1814 it was part of the salt reservation, undoubtedly had a depressing effect upon its size and upon the character of its improvements. For a number of years, however, it did an amount of business out of all proportion to its size, and most of that business was directly related to the salt trade. As early as 1807, Cumming wrote that it possessed a more enterprising appearance than he had seen west of Pittsburgh.[9] It was the place of shipment for much of the salt, and as a consequence, it soon became a center of keelboat traffic. The building and outfitting of boats at its wharf, the making of barrels, etc., were all subsidiary industries. The opening of the United States Land Office in 1814 was a direct response to the movement of population into the area, and in the selection of Shawneetown in 1817 as the site for one of the territorial banks, the revenue which would come to it from the salt works was of considerable moment.[10]

The early history of the town of Equality was also intimately connected with the salt trade. The offices of the salt works were located there;[11] it was the place of residence of many of the laborers, and, after the construction of the locks and dams at Saline Mines and Island Ripple which were necessary to make the Saline River navigable, it became a second port for salt. Elizabethtown, founded in Hardin County in 1808, was the logical outgrowth of a ferry established where the trail which led from Nashville, Tennessee, to the salt works crossed the Ohio River.[12]

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8. Wood, John, *Two Years in....the English Prairie....1823.* (Reprinted in Thwaites, *E. W. T.*, X.), p. 254.
9. Cumming, *Sketches of a Tour to the Western Country*, 1807-9. (Reprinted in Thwaites, *Early Western Travels*, IV.), p. 271.
10. See editorial from *Western Intelligencer* for Jan. 1, 1817, in Buck, 148-150.
11. *History of Gallatin, Saline, Hamilton, Franklin and Williamson Counties, Illinois* (Chicago, 1887), p. 122.
12. Smith, George Washington, *History of Southern Illinois* (Chicago, N. Y., 1912), I., 479.

Much salt was hauled in wagons on that road, or carried on horseback. It was only one of a number of such roads which led to the salt works from all directions. Some of them were short and perhaps illy defined, while others were well made and extended long distances, as, for example, the one which crossed the state to Kaskaskia. While these roads were built largely for the purpose of facilitating the movement of salt, they served also to encourage settlement in the areas through which they passed. Such was true on the Kentucky side of the river as well as in Illinois.

The number of people who came from the South for salt strengthened the bond between the two regions and rendered more difficult the proper adjustment of the slavery issue in Illinois. The Wabash Saline was responsible, in large measure, for the virtual existence of slavery in territory which has been prescribed by Congress as free, for much violent pro-slavery agitation in the early days of state-hood, and for a political fight which all but disrupted the commonwealth. From the time when Governor St. Clair, by his interpretation of the Ordinance of 1787, permitted slaves which were owned outside the Territory to be brought into it for the purpose of working at the Saline, until 1824, when the call for a convention for framing a new state constitution which should legalize slavery was finally defeated, the salt interests led the pro-slavery fight.[13] The fact that the first Constitution did not prohibit the institution entirely and at once, but contained instead a temporizing clause which permitted slave labor at the Saline until 1825, indicates the hold which it had gained upon an industry that was felt to be essential to the welfare of the state. At the same time, it is suggestive of the place which the industry occupied in the life of the people. The large number of workmen required not only in the actual manufacture of salt, but also in cutting and hauling wood for fuel, in making barrels, etc., made the low cost of slave labor and its perpetuation seem a matter of much moment to the operators of the works. According to Prof. Worthen, the number of employees sometimes ran as high as one or two thousand.

13. See Harris, Norman Dwight, *Negro Servitude in Illinois;* Flower, *English Settlement;* Pease, Theodore Calvin, *The Frontier State.*

Also, because of the revenue which accrued to the state from the Saline, certain persons not connected with the works favored the legalizing of slave labor. For some years after the transfer of the salt reservation to the State in 1818,[14] the rentals therefrom made up a considerable proportion of the entire income of the state. In 1821, for instance, they amounted to over twenty-five per cent of the total revenue.[15] The claim of the leasees that without slave labor the works could not be kept open was thus regarded with much uneasiness by some of the inhabitants, who, in the end, cast their lot with the pro-slavery party—for the time being, at least. All such arguments were unavailing in the final outcome, however.

The later history of the Saline; its decline due to the competition offered by Kanawha salt and the growing scarcity of fuel nearby; the gradual sale of the woodland reservation[16] and then of the Saline itself, with the utilization of the moneys received in public improvements; the second period of prosperity through which it passed after the discovery that the coal which lay close at hand could be used for fuel and that from deeper wells could be obtained stronger brine, and then the rapid decline which followed the coming of the railroad into the region, end the story of man's response to one of the least of the state's resources and yet one of the greatest measured in terms of influence exerted. Only a few of the many influences have been traced; the others await our inquiries.

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14. As the territories which contained salt sources became converted into states, Congress transferred the salines to their jurisdiction and gave title to them. The transaction was, in every case, part of a pact between the United States and the state seeking admission to the Union, whereby, in return for the salt lands and various other emoluments (school lands, funds for college, or for University, and for the improvement of roads and canals), the state was to provide "by an ordinance, irrevocable without the consent of the United States," for certain tax exemptions in accordance with the government land policy. Illinois had to bind herself also to the principle of equal taxation for resident and non-resident proprietors. (See Thorpe, *Constitution and Organic Laws*, II., 969-970).

15. Pease, *Frontier State*, 62.

16. The reservation in 1816 covered 98,500 acres, of which a large part was woodland. At first, the wood was cut and hauled to the furnaces which were situated near the wells. Later, the furnaces were moved back into the timber and the water was pumped to them through wooden pipes.

Papers on Medicine and Public Health

RELATIONSHIP OF DENTISTRY AND MEDICINE TO THE PEOPLE'S WELFARE OF THE STATE, AND WHY

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Taken at one dose, this is a big question. I believe that any profession, properly handled, is of such great benefit to the community that it can and *does* leave its impress upon the people of the community. The intellectual side works so thoroughly that much of what was told remains, and eventually the public respond to good influence, when shown it is for their benefit. These associated professions stand side by side, but with fear on one side and friendliness on the other, and yet each is to relieve suffering and even more, to prevent suffering, or trouble; hence *prevention* is the theme of today. Why may this subject be given here, when the Academy meets? Because of its breadth of scope and character. Again, because we represent sciences and professions so closely allied that we cannot do without one another. The people of the state should have the best we can give. Our schools and colleges are the stepping stones for future advancement in all that elevates and teaches, and to this end your teachers should be paid so that you receive value for your future life work.

Without the aid of Science, be it Biology, Chemistry, Dentistry, Medicine, or their adjuncts, you cannot understand the body needs. Development of the human body is a serious and far reaching problem, for the Nation depends for its very life on the best that is in us. Hence, guard your youth, your health, your home, your work and play.

The physician advises, treats and helps you in sanitation and health. The dentist watches your food portals, to assist the physician and to aid digestion. The botanist provides the plants for samples and aids in beautifying the land with the forester and provides the health and quiet shelters in our woods. The chemist guards the water and food supply and aids the arts and industries in many thousand ways, and

these last two co-operate with the bacteriologist, physician and specialist. Remember, for this reason, no one man can know it all.

It seems as if in these days, "Specialism" is tending almost too far, and certainly some are too young and rapid in trying to succeed to that title before sufficient general practice has been studied. Experience is the best teaching for specialism, with a thorough, careful analysis of years of observation, together with research studies of the necessary kind, and less with the idea of a Ph. D. degree, which hardly fits the science group so much as the classic or literary ones.

To resume—Dentistry is really a part of medicine, just as much as the eye, the ear, the bones, etc. A certain amount of mechanics is necessary to all. And like a huge, first class engine of the highest type, the body must be treated as such and carefully cleaned, oiled and guarded. In spite of much work, dentistry, for some reason, creates fear, even more, perhaps, than surgery. Why? Because a child is early told by its mates that a dentist hurts. Hence, see to it that you take your child to the doctor and the dentist early and let him learn they are his friends. You can hardly go early enough, for like the parent and the rod, the sooner the better. Be kind, but firm, and mean what you say and do not vaccilate. During infancy, many troubles creep along insidiously, which could be prevented either by physician or dentist, for by co-operation, they aid and advise the parent of danger. For example, a bad arch or irregularly placed teeth become a danger in child development and should receive early correction. You would not wait if it were a fine new tree! You must breathe through the proper channels, and how can you with a ¼—1″ width of mouth and your nostrils curved, closed or obstructed, when each of these conditions predisposes to adenoids, tonsils and catarrh? If adenoids are present, then the jaw develops badly. Pressure takes place and injures the nerves of the face, eyes, ears, nose, etc., and even may carry on these changes in remote parts of the body. A tubercular hip shows by pain and lameness in the knee, and like inflam-

mation of the bone, in its early stage, has been mistaken for cold, or growing pains in children's legs; when, if it had been attended to, many a heart lesion, like endo- or pericarditis, with arthritis, or so-called rheumatism, would have been prevented and a child saved from being damaged for life.

A mouth full of dirty decaying teeth is a danger to all organs near and far, whether tonsils, eyes, nose, or glands of head and neck. Think of swallowing many germs with all your food, pus in quantity, foul odors, etc. Few things are worse than a bad breath, mouth or nose. No wonder the stomach, liver and intestines object and by inactivity or an overload, refuse to work. Then the fermentation and decay begin to overwhelm the system and clog it up and we soon get crossness or irritability and the mother says, "I wonder what has got Jimmie today!" The lad feels bad, has foul taste, feels thirsty, has fever and headache and Nature steps in and tries, perhaps, to help by unloading through vomiting or diarrhoea. The castor oil and such remedies are only an aid if the sore, poor teeth with holes in them are put in good shape, just as the farmer's fence must be kept up, or he knows trouble will come. To prevent is better than to cure. Cavities in teeth open up the nerves or pulps, causing sensitiveness and pain. Then come fear to eat, bolting of food and dread of dentists and long and painful or tedious sittings. The use of drugs follows to kill or cure pulps, and so pulpless teeth and more troubles may come. You all know what happens to dead or dying trees. Teeth are the same, and great is the loss later on! New ones, not so good, are put in and though a great help in looks and force, yet lack the value of good, sound live teeth. Extractions and abscesses may precede, and who does not dread and fear these! We must be on guard and not lay all ills of mankind to the teeth, for we know there is a great tendency today to be too radical. Rheumatism is seldom if ever cured solely by extraction and erradication or destruction of the alveolar plates. Foci of the bacteria are present all over the body and too far to be reached entirely by the scalpel and chisel.

Look to your body upkeep, your immunity or reserve forces. As every farmer knows, the soil needs treatment and rotation

of crops to prevent slow or bad growth, smuts, disease and failures, and the best of seed is needed. Is that sufficient even in good weather conditions? No. Cultivation plays one of the biggest parts, in dry seasons, and at all times. Just so in the matter of health, dentistry and medicine. If these were taken care of, we would have fewer feeble-minded people and morons, and fewer cases of insanity, tuberculosis and cancer. Where there are badly developed jaws and arches, we also note an increase in asthma, tuberculosis, ear troubles and deafness, a lowered mentality and lessened resistance to disease, to courage, to development, physical or mental, and backwardness in growth and character of bone. Needless to say, such a youth grows up weak in character and yields to temptation, maybe alcoholism, the forerunner in many cases of tuberculosis and cancer. The irritability and nervousness create a craving or desire for stimulants of some sort. Smoking is common and easily induces the weakened mucous membrane to disease, and the air spaces and eyes are involved. Very soon the digestive tract is injured. How far reaching these seemingly remote symptoms may be, those working in co-operation, like the dentist and rhinologist, the oral surgeon or stomatologist and the physician know.

Why do parents shrink from having their defective children examined early, and worse, delay treatments or operations? Take the child's side of the question and ask anyone who has a cleft palate, or hair lip, or injury on the face, how he feels! They all wish something had been done to give them a clean or comfortable plastic operation, and it is *no kindness*, neither is it aiding their health or minds, to neglect your duty. If you fear, stop and reason a moment—put yourself in the others' place—would you like to be the injured party? What right have you to do things that injure and give your child such a life of misery and inheritance? They are innocent of their birth and you should do all in your power to give them as perfect health and body as it is possible. Life is a hard struggle at the best and you should help, not injure. If misfortune comes, at least get the men or women most fitted for the purpose to help you to remedy it as early as possible.

Train body and mind in the healthy way. The State and its taxpayers provide aid for all, and they should not be burdened by degenerates, criminals and ill-doers, when perhaps these persons could be helped to regain their lost power by appropriate treatment in the hands of properly trained, accredited research men and women, who spend their days in hard study and desire to help the afflicted. It is true, more careful legislation should be had, less law making and opening doors for faddists, and better laws. Surely the enforcement of justice for those who do conform to the rules, to have the right to practice legitimate medicine and dentistry, should be through only *one* portal of registration and so safeguard the commonwealth of the State. There is little doubt that if the criminal element had been disciplined rightly in early youth, their bodily health attended to from birth, their minds and bodies could be kept in rightful exercise with a proper amount of work and play. They could be taught respect for others, a higher moral code of study and pleasure, and an individual sharing of learning and labor. The hand of good fellowship would be able to withstand the storms of egotism, socialism of the narrow kind, and would prevent labor's interference with the desire to compete with industrial advance, for those who strive to become expert in their chosen life work.

The time to treat a human being for constitutional defects is in his infancy and childhood, not after manhood has confirmed his anatomy and physiology in its bad habits.* Today offers many opportunities never even dreamed of, for the rural communities can and do have the motor dentists and nurses. The auto brings the physician, and the various community and state gatherings offer lectures, clinics and schools in all varieties of work.

Look to your children and don't forget the parents, all who do need attention, and trust to your good faithful family friends, the true doctors.

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*V. A. Latham. "Relation of Oral Hygiene to Man and His Community in Its Widest Application." Oral Hygiene, March, 1921, p. 363.

DISCUSSION OF DR. LATHAM'S ADDRESS

Dr. C. W. East stated that the remarks of Dr. Latham on the end results of operations in the mouth are of great value. "Too often in reconstruction work, temporary improvements are achieved and the chance for permanent improvement sacrificed."

Dr. G. W. Boot referred to three specific cases that illustrated admirably the points brought out by Dr. Latham. Each case referred to had formerly been considered hopeless.

Dr. Latham thanked the members and closed by adding that early work on young people in preventive medicine brings about better oxidation, physical developments, prevents lowered mentality, and aids specialists to diagnose remote conditions.

ON THE TEACHING OF EAR, NOSE AND THROAT DISEASE

G. W. Boot, M. D., Chicago

Eighteen years spent in the teaching of ear, nose and throat diseases have resulted in the development of definite convictions in my mind as to how this subject should be taught. I wish today to speak of two phases of this subject. The first concerns the teaching of the subject and the second the preparation of teachers.

The Model Medical Curriculum published by the American Medical Association in 1909 allotted 90 hours to the teaching of Ear, Nose and Throat Diseases, of which 40 hours were to be given to theoretical instruction, 40 hours to sectional teaching and 10 hours to quizzes, etc. In the University of Illinois the time devoted to this subject is only 60 hours, of which didactic teaching is given 16 hours, clinics 26 hours and sectional work 18 hours. This is but two-thirds of the time allotted by the Model Medical Curriculum and much less than is given at Rush Medical College where the requirements are 1.2 majors, a major being 60 hours of didactic work or 120 hours of clinical or sectional work. Loyola requires .8 major and Northwestern 16 hours of clinical work and 96 of dispensary.

When we consider the importance of ear, nose and throat diseases for instance; how most cases of meningitis have their origin in the ear, nose or throat; how the ear includes two senses, hearing and balance, and how important hearing is to our daily life and how completely dizziness due to disturbance of the organ of balance can interfere with our daily work; how adenoids cause deformities of the mouth, teeth, nose and chest; how often rheumatism, endocarditis, heart disease, appendicitis, gall stones and so on have their origin in the tonsils; how often tuberculosis is the result of defects in the nose and throat; then we have some small idea of how important these organs are in our daily life and how important it is that our physicians should be properly instructed in this subject.

The time allotted to the teaching of this subject is all too short, but it is not of the shortness of the time that I particularly complain but rather of the way time is wasted in teaching the subject.

To my mind, time spent in didactic teaching of ear, nose and throat diseases is time practically wasted, as is time spent in having students examine the normal subject and time spent in quizzing. In a branch where individual work is as necessary as it is in this, where but one student can see a drum membrane at a time, or the interior of the nose or larynx, why waste time giving didactic instruction when the student can read the same thing in any good text book? When there is so much to be seen and too little time to see it in, why ask the student to spend time looking at normal ears, noses or throats?

When no one but the assistant and often not even the assistant can see just what is being done in a mastoid operation or an accessory sinus operation, why spend time giving operative clinics of mastoid operations, nose operations or throat operations?

In other words, time devoted to didactic teaching and clinics is time largely wasted because the didactic work can be gotten just as well from the text book, and the student cannot see in the clinic anyway.

I repeat, the teaching in this subject, if it is to be of value, must be individual, so why not set the student at work at once examining patients? The object of teaching this subject is not, as some teachers seem to think, to teach the student just as little as possible so he will refer more patients to the professor who taught him, nor is it to enhance the glory and reputation of the teacher, but is to prepare the prospective physician to care properly for the ills of his patients and in this the public has a most vital concern. The time is past when medical schools were run for the glory and reputation of the professors.

I would suggest as a proper way to teach ear, nose and throat diseases, that didactic teaching be cut down to a minimum or dispensed with altogether, and that clinical

teaching, that is operative clinics, be very much reduced. Instead give all the time possible to examination of patients by the students. I know nothing that palls on the student so soon as examination of the normal individual, so waste no time having students examine each others ears, noses or throats. They can learn the technic of examination just as well on the patient and learn something of disease at the same time. They will run across plenty of normal ears, noses and throats in doing this so that they will have ample opportunity of getting a normal standard for comparison.

If at the State University the classes were divided into sections of not more than six or eight and given fifty hours of such practical work instead of the eighteen hours now required, while the didactic and clinical work was cut to ten hours, I am sure that the graduates would know much more about the subject than they do now.

I would suggest that the following is a practical way to get the most out of this work. Divide the class into small sections, require each student to have access to a good text book, and to own the common instruments for examination, such as a set of ear specula, a nose speculum, a tongue depressor, two sizes of throat mirrors and an applicator. Then at the beginning of each hour assign a patient to each student for examination. Let the class spend a half hour examining the ears, noses and throats of their patients under the guidance of the instructor. At the end of the half hour call the class together and have each student report on his case while the instructor examines the patient and sees that the student has reported correctly. If he has missed an important point let the instructor call his attention to it, and possibly require the student to re-examine his patient. At the same time let the other members of the class make suggestions, ask questions, and in other ways discuss the case. If the case has any unusual points about it, let all the section see it. Between this session and the next one require each student to read up his case and, if desirable, present an outline in writing at the next session of the section. In addition to this, assign each student a subject for a paper at the beginning of the

semester. The object of this is two-fold—to show the student the immensity of the specialty and to get him into the habit of using the library. For this purpose the subject should be one not easily copied from his text book, such as "A Sketch of von Helmholz," "A Review of Wilhelm Meyer's Original Paper on Adenoids," "A Review of Hutchinson's Paper on Hutchinson's Triad," "The Anatomy of the Ear in Birds" and so on.

As to the second phase of my subject, it is well recognized in other lines of teaching that research is necessary to the development of good teachers. In the matter of research in ear, nose and throat diseases we are easily behind every other civilized country. It is true that we have a few large institutions devoted to eye, ear, nose and throat, such as the N. Y. Eye and Ear Infirmary, and the Illinois Charitable Eye and Ear Infirmary; but who ever heard of any reports of original research coming out of them? I have never heard of a single section of a temporal bone affiliated with so important a disease as Otosclerosis ever being in America. When we want to get any real knowledge of the Pathology of the Ear, Nose and Throat we are compelled to go either to German, Austrian or Swiss literature. We have no men trained in research work along this line. We have no facilities for research work along this line. Nowhere in the United States is there any large collection of anatomical specimens of the ear, nose and throat that can compare in any way with the material in the Hunterian Museum in London.

Now the opportunity to correct their faults is at hand. In Cook County Hospital is an abundance of material for instruction of students in the manner I have outlined. The attending men have begged for the chance of using it for teaching purposes, but we are almost invariably turned down by the colleges, for it would upset the established regime, or it would create rival courses, a state of affairs which to my mind is highly desirable, for nothing could do so much to stimulate a teacher to do better work than the knowledge that someone else would get the students to teach if his work were not satisfactory.

As to research, the State of Illinois is pledged to build a hospital in connection with the State University. Let the State give this institution ample means to carry out research in ear, nose and throat. Let it have a paid director in ear, nose and throat with paid assistants and technicians, ample dispensary facilities and laboratories, and let any one entering the hospital do so with the distinct understanding that in case of death a post mortem examination is to be held. Then let the men engaged in teaching have a chance to develop their ideas, and a real start will have been made in the study of ear, nose and throat diseases and we will soon be able to be independent of Europe for what we know about our subject.

DISCUSSION OF DR. BOOT'S PAPER

Dr. Latham heartily endorsed the paper. She urged that opportunities be given to research volunteers, provided laboratory equipment is given. These on the practical work done should be admitted for degree. Close relationship between the rhinologist, laryngologist, aurist and dentist for mechanical opening of the air passages at an earlier age than usually done is a great help. Clinical practical work by students in all public State institutions should be increased.

Dr. East expressed a keen appreciation for the research work carried on by Dr. Boot and lamented the fact that endowment funds are woefully lacking in the United States for research work.

The discussion was closed by Dr. Boot, who pointed out that his experience showed that the research work in the past in this country had depended almost wholly on personal ambitions that were often satisfied by sacrificing financial gain.

THE TEACHER IN RELATION TO COMMUNICABLE DISEASES OF SCHOOL CHILDREN.

E. D. WALKER, M. D., LITCHFIELD, ILL.

As stress is being laid more and more upon the school as a center for effective public good, the writer wishes to present a plan by which the school may be made a means of materially reducing communicable diseases of school children.

One has only to consider some of the losses from this source to realize the important community good in reducing the number of casualties from infectious diseases. "If knowledge now existing among well informed men in the medical profession were actually applied in a reasonable way and to a reasonable extent, forty-two per cent of persons in the U. S. who annually die of communicable disease could be saved.[1]"

The estimated loss of life from infectious diseases contracted in the school room, for a selected year, is as follows:[2]

(For the Registration Area)—10 States.

Colds, Bronch. and Pneum.	5-9	1906;	10-14	925;	15-19	1438
Influenza (Not Epidemic Year)	5-9	122;	10-14	73;	15-19	119
Smallpox	5-9	6;	10-14	6;	15-19	17
Mumps	5-9	14;	10-14	9;	15-19	9
Tonsillitis and Diptheria, Croup	5-9	3028;	10-14	713;	15-19	239
Measles	5-9	588;	10-14	152;	15-19	112
Whooping Cough	5-9	228;	10-14	17;	15-19	10
Scarlet Fever	5-9	1731;	10-14	442;	15-19	232
Meningitis	5-9	683;	10-14	365;	15-19	294
Totals		8306		2702		2470

The financial loss, based on an Illinois estimate for an influenza campaign, counting treatment $10, loss of time $15, funeral $100, life at $3,000, apportions ages 5-9 at $25,956,250; 10-14, $8,443,750 and 15-19, $7,718,750, approximating $42,000,000.[3]

Based upon the foregoing three period school ages, the per cent preventable, for the selected communicable diseases, follows: 5-14 years, colds, pneumonia and accessory, 50%; influenza, 50%; smallpox, tonsillitis and diphtheria, 70%; measles, 40%; whooping cough, 40%; scarlet

1. This per cent was computed by a chief with thirty (30) experts in health data.

Authority: 2. U. S. Mortality Statistics and causes of death for registration area.

3. Ill. Statistics for the State July 1, 1918, to June 1, 1919.

fever 50%; meningitis, 70%. For 15-19, similar except whooping cough not reckoned. Estimate average preventable, 50% or 4,200 at 5-9, 1,350 at 10-14, and 1,235 at age 15-19. Total deaths, 15-19 preventable about 24,000.[4] 5-14, 33,500.[5]

In 1918, 289.9 per 100,000 for influenza, 284.3 per 100,000 for pneumonia. Influenza, 3,517 cases and 396.6 deaths per 100,000 population, 112.7 per 1,000. $73,710,000 total cost for influenza 1918-19. Whooping cough 10,000; ill 190,000. Scarlet fever, 9,000. Diphtheria and croup, 18,000 annually. Pneumonia, 132,400 lives annually.

Pasteur has prophesied: "It is within the power of man to rid himself of every parasitic disease." "Within natural limitations a community can determine its own death rate."[6]

"Instructions in the methods of preventing disease should be an essential part of our system of education and no individual should have completed his education without the knowledge of how communicable diseases are spread and prevented."

To materially limit the incidents of these diseases, and thereby preventing much of this loss, I desire to submit for your consideration and, I trust your very earnest discussion, what seems to me a very simple plan.

My plan would be to have the school board of each community compel the teachers to familiarize themselves with the easily recognized symptoms which occur in one or more of these infections.

Then have the superintendent of each school insist upon an inspection of each pupil—every morning before classes begin. Such inspection, according to the keenness of the ob-

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4. Fisher's Average and U. S. Mortality Statistics.
5. U. S. Mortality Statistics and Fishe Preventable Table.
6. Various Official Pamphlets.

server, would require about twenty seconds. The routine inspection should be divided or modified, in accordance with each teacher's plan of organization, in the opening period.

The inspection should include a search for the following symptoms, in the order named:

1. Rash of *any* kind on face, neck or wrist—Skin.

2. Eyes—Redness, watering or puffy.

3. Mouth and throat—bright redness of tongue, gums, pharynx, and tonsils; white spots on pharynx, tonsils, gums or *between* cheek and gums.

4. Under the jaw and along the neck palpable swelling of glands.

5. General symptoms: Nausea, malaize, unusual inattention, coughing and sneezing, hoarseness or unnatural tone of voice.

The instruction of the teacher so that she can recognize these symptoms should be made compulsory and should be given by a physician and made a part of a teacher's certificate requirement.

In order that the school board can put into effective operation this requirement, summer courses of instruction should be given by physicians whose sympathy and experience bring them in touch with the most vital relationships of pupil, teacher and family doctor.

The teacher should be given authority by the superintendent of schools to dismiss any pupil suffering from any of the symptoms mentioned. The teacher should not permit return to school until he could bring with him a physician's certificate of good health.

To sum up: Every teacher should learn to recognize a sick child. Every teacher should make a morning inspection of each pupil. Every sick child should, by the teacher's transfer slip, be sent home for the parent to immediately secure the pupil's careful examination by the family doctor.

The state and local boards of health should co-operate with the school board, school superintendent, the teacher and family doctor in establishing and enforcing this

routine. The attention of the public should persistently be called to the importance of co-operation in this movement.

DISCUSSION OF DR. WALKER'S PAPER

Dr. Pollock suggested that a great many Boards of Education might profit by spending a little more money for personal study in Economics that would be directed along these lines. Dr. East emphasized that special knowledge relative to the control of communicable diseases is essential and that therefore the link of Nursing Services in this connection could not be overlooked.

In this connection the question was brought up of the importance of general publicity and education along public health lines. It seemed to be the general impression of the Section that very little had been and is being done in the way of general education of the public. Mr. Richardson stated that the State Department of Public Health not only maintained constant educational service that embraces special bulletins, motion picture films, lantern slides, posters, exhibit material, and demonstration service but it carried out such special programs as Health Promotion Week and Better Baby Conferences.

THREE HELPFUL AIDS IN THE DIAGNOSIS OF GALL BLADDER DISEASE

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Gall bladder disease so frequently disguises itself by a long train of symptoms, stimulating disease of other organs, that any additional means of obtaining definite information is welcomed. Careful study of a rather large series of cases prompts me to emphasize the aid one derives from three sources.

1. Trans-duodenal drainage of the gall bladder.

2. Examination of the gall bladder region using recently developed X-ray technique.

3. Checking the pathological anatomy of such cases as go to operation, with reference to the relation between symptoms and the pathology in situ.

Trans-duodenal aspiration or drainage of the gall bladder is readily applied as an adjunct to the fractional method of examining the stomach contents. The usual small tube, with perforated metal olive at the end, is allowed to pass into the duodenum, after the fractions have been aspirated from the stomach, the time of passage being noted by the change in reaction, or the appearance of bile, and checked as to the position by fluoroscopic examination. After a couple of specimens have been obtained from the duodenum, solution of magnesium sulphate is allowed to flow by gravity, and aspirations follow at fifteen minute intervals.

Disregarding the question of duct contents, the appearance of 30 to 50 mils of a bile differing in color, consistency, and turbidity from the specimens which precede and follow it, is taken as indication that this bile comes from a different source from that with which it is contrasted. Repeated trials warrant the assumption that this bile comes from the gall bladder. If in addition to these physical differences, microscopic and cultural examinations

show pus and organism of different type than those predominating in the duodenal content, before and after this portion, the deduction follows that the contents are not only from the gall bladder, but that there are signs of cholecystitis.

It is true that it is not possible to drain every gall bladder even after repeated attempts, but when positive findings are secured, they are a distinct aid. I have recovered typhoid, para-typhoid A. & B., colon, streptococci, diplococci and pyocyoneus organisms. Many times I have recovered the same organism on repeated trials upon one individual.

THE ROENTGENOLOGIC AID

Attempts directed toward visualization of pathological gall bladders require infinite patience and innumerable films. The technique as developed by Dr. Robert A. Aarens of Michael Reese Hospital, with whom I have cooperated in all my roentgenologic examination, is as follows: The patient lies face downward on the plate and compression is used to assist in immobilizing the part. Immobility of the diaphram is of the utmost importance as the slightest movement will blot out the shadow of the gall bladder. It is, therefore, very essential that if the patient cannot or does not understand how to hold his breath that he be taught how to do so.

A duplitized film with a double screen and a radiator type Coolidge tube taking 25 M. A. is used. The penetration is varied for each patient. A series of from four to eight exposures is made with slight differences in the penetration of the ray. The first exposure is made with a penetration as soft as it is possible to use to get through the patient. Each successive exposure the penetration is increased by about ¼" so that when the series is completed, the plates will vary from an under exposure, to an over exposure with one or two perfect films in the series. The time for each exposure varies from four to eight seconds, depending on the patient's size, the same time being used on all exposures in the same patient.

This shows a shadow of the liver and kidney, and repeatedly a shadow of the gall bladder can be demonstrated. An accurate knowledge of the different types of gall bladder that are to be met with is essential. It is not necessary to show the presence of stones to outline a pathological gall bladder.

Pathological bile, thickening of the gall bladder wall, and adhesions combine to give a shadow so dense that it will be cast upon the film if the proper technique is employed. If the stones are present they may cast a shadow if of sufficient density. On the other hand, some cholesterin stones have given lighter areas than the surrounding medium; in either case the result is apt to be a mottling or tessilation of the area within the gall bladder shadow. A normal gall bladder does not differ in density from the surrounding structure sufficiently to throw any shadow.

In addition to these findings others are of value, such as local tenderness under the fluoroscope with accurate localization; immobility of the duodenum, where the bulbus is perfect in outline, and not of the physical type where the bulbus is normally immobile; at times a high help hepatic flixure in addition to other findings; in other cases, a gall bladder seat shown in the shadow of an otherwise normal duodenum; again a number of cases have been noted in which the duodenum has taken an unusually wide outward curve to the right, as though due to encroachment of the head of the pancreas. While simulating carcinoma of the head of the pancreas, which must always be considered, we have never seen a carcinoma of this type but rather have found a pathological gall bladder adherent to the head of the pancreas.

Lastly complete the diagnosis, not as to fact, but as to origin or contributing cause, when the patient goes to operation.

Here I want to emphasize the point that facts are frequently overlooked which, while of no import to the surgeon at the time, may yield a wealth of information to the internist who scrubs up, and examines carefully the pathology before any of the relations are disturbed, then follows every step of the operation.

The adhesions to the various organs may be of help, explaining certain symptoms referable to the colon or stomach, but particularly do I wish to emphasize the finding of the anomalies of the ducts and blood vessels, a fact well brought out some time ago by Dr. D. N. Eisendrath in a masterly article on the subject. When one finds a sessile gall bladder with practically no cystic duct, he can understand how the adhesions to the fundus caused an angulation which produced colic quite as severe as though brought about by stones. Again, the parallel cystic and hepatic ducts, or the anterior or posterior spiral placement of the cystic duct, as it curls about the hepatic before it unites to form the common, or the constriction of a duct by an abbarent blood vessel, explain symptoms which were so puzzling.

DISCUSSION OF DR. WRIGHT'S PAPER

Relative to the relation between gall bladder infection and the typhoid carrier, Dr. Thomas G. Hull called attention to the frequency with which carriers are being referred to the State Department of Public Health by physicians.

Dr. Hull stated that from a public health standpoint, Dr. Wright's paper is most interesting. Continually the laboratory is uncovering typhoid carriers and the cry is continually coming up to show how such persons can be cured.

THE FILTERABLE VIRUSES

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There exists just at the range of vision of our most powerful microscopes, or beyond this range of vision, a large number of microorganisms, the identity of which is uncertain. They are called "filterable" viruses because they will pass through our best clay filters. In 1898 the first of these was discovered by Loeffler and Frosch, in studying the foot and mouth disease of cattle. The same year Beijerinck demonstrated as the cause of mosaic disease of tobacco, a filterable organism. In passing it is interesting to note that as in bacteriology, where the first diseases studied by Pasteur were in the industries, so in this new class of organisms, initial studies were made upon diseases of animals and plants. The application to human diseases came later.

During the next few years, a large number of diseases were investigated in various parts of the world, adding much to our knowledge concerning filterable viruses. By 1913, more than forty diseases were attributed to this cause. Among these were diseases of plants, as the mosaic disease of tobacco; disease of animals, including horses, sheep, cattle, swine, dogs, guinea pigs, rabbits and rats; diseases of birds, especially black birds, and chickens; and diseases of man. The latter list includes small pox, scarlet fever, measles, polyomyelitis, trachoma, rabies, Dengue fever, yellow fever and Rocky Mountain spotted fever.

Recent literature, especially since the war, has been full of work confirming the filterability of the organisms of these diseases and methods and means of their prophylaxis. Of more interest, however, are the new diseases of man which are included, namely, influenza, epidemic encephalitis, trench fever and the "common cold." There is no need to mention the ravages which influenza has wrought all over the world in the last three years. The discovery of the causative agent is a great step toward its final eradi-

cation. Epidemic encephalitis is a new disease little known till the last two years. Its long course however makes it a dreaded affliction and its eradication imperative. Trench fever is of little importance in this country in times of peace at least. The common cold is the most costly of all of our diseases. While various factors are concerned in the common cold, a filterable virus has recently been isolated as one excitant. It is gratifying to know that in all four of these diseases, priority of investigation as to the real cause belongs to American scientists. No longer are our laboratories dependent upon Europe for stimulation.

The nature of the filterable viruses as a group is uncertain. Park divides them into three classes; first, diseases produced by filterable agents of unknown morphology, an example of which is foot and mouth disease. These organisms are probably too small to be visible with our most powerful microscopes. Second, diseases produced by filterable agents shown to be visible. Polyomyelitis comes in this class, the virus of which can barely be seen with a microscope. Third, diseases produced by viruses of questionable filterability. In this class are several diseases, one of which is smallpox. Another classification which might be used is a division into plant and animal kingdoms. In the plant kingdom are those viruses closely related to the bacteria, as polyomyelitis and encephalitis. In the animal kingdom, one disease, the agent of which in certain stages is filterable, has lately been shown to be related to protozoa, namely yellow fever. Noguchi has very lately shown this to be Leptospira icteroides. Probably other diseases, especially those in which mosquitos are involved in transmission, belong in the same group. Both Williams and Hawkins have claimed that the virus of rabies belongs among the rhizopods.

Lately an Italian investigator has shown that any substance which will cause the clumping of the viruses makes these organisms easy to study with the microscope. Great possibilities lie in this field.

There are still many problems to be solved. One that is to be emphasized especially is that more attention be paid to this group of organisms. There should be devised more

accurate methods of study, including possibly zoology and botany. When one thinks of the immense amount of work done in attempting to isolate the cause of influenza, much of it of the crudest nature, it is no wonder that the results were negative. The ability to run around with a cotton swab in either hand is not sufficient training to cultivate such delicate organisms as the filterable viruses. Not till the causative agents of these diseases are demonstrated can we go very far in either prophylaxis or treatment. It is a satisfaction to know that already for several diseases, especially smallpox and rabies, we have an absolute preventative in vaccine; and in at least two diseases, polyomyelitis and hog cholera, a curative serum has been produced. The outlook for future work in this line is bright.

DISCUSSION OF DR. HULL'S PAPER

Is there any similarity of mosaic disease of cucumbers and tomatoes in these filterable virus forms? Better staining methods by use of mordants and testing out on the line of chemical agents and media were suggested. Mention was made of the work of Prof. Ernst Bessey of Michigan Agricultural College and his colleagues in mosaic disease.

Dr. Latham agreed with Dr. Hull in his plea for co-ordinating the several sciences relating to bacteriology in order to more readily enhance the correctness and extensiveness on the results along the lines that deal with virus. Dr. Pollock felt that such co-ordination and co-operation would result in great practical good so far as junior sanitary leagues etc. in connection with schools and school teaching is concerned.

AXILLARY GLAND INFECTIONS AND THEIR TREATMENT

JOHN O. CLETCHER, M. D., CISCO

The purpose of this brief paper is for the prevention of local and constitutional disease and the conservation and treatment of the axillary glands. Although there has been little written on axillary gland disease, it is most interesting from a health and medical standpoint. Probably no group of lymphatic glands, except the cervical, are called upon as frequently to stop the progress of infection bound vascularwards, as the axillary glands. In fact, they do their work so well and so infrequently become dangerously involved in ratio to the numerous infections of the upper extremity, scapular regions and outer chest wall, and *mamma* that their presence is only realized when they become involved. (The public is much entitled to a fair conception of the hygienic and preventive measures.) This group of glands is slightly protected from infected wounds of the areas of their lymph channels drain. There are some small glands in the arm and fore-arm (these are often missing), and the epitrochlear of the elbow are the only nodes to delay infections entering directly into these glands. The so-called "Kernels under the arm" are of frequent occurrence and at first are taken lightly by the patient, especially if they are not having intense pain at the focus of the infection. As long as the glands are not swollen and painful neither the patient nor the physician feels anxious; but when chill and pain appear, and the red streaks form in the skin between the focus and the axillary glands, radical treatment of the infected area should be maintained and assistance should be given the glands in arresting the progress.

We have both the acute and chronic infections, but in the chronic infections we have more time for study and treatment; therefore only the acute conditions can be considered here.

The etiology is clear but extensive. Predisposed by age we find more cases in the young and in the laboring classes who are most active, certain occupations incurring special

hazards in hand and arm injuries. Males are subject to these causes more than females. But, many cases are found in the females of child bearing period, from infected milk ducts and fissured nipples, females also from depilatory operations on the axilla, causing infections of the hair follicles. Many cases arise from constitutional debility and sedentary habits in persons who have thin loose skin and brittle nails causing hang-nails, which make ideal focci of infection. Gardners, farmers, carpenters and sportsmen should be careful. Formerly surgeons had frequent axillary infections, but since asepsis is more perfect we seldom see a case in surgeons.

Skin diseases cause many cases, such as ring worm, seborrheic, dermatitis, erythema, intertigo, eczema, scabies, furunculosis.

Primary infections may enter the axillary glands by direct contusion, subjecting the glandular tissue to infectious material such as traumatic injuries from punctures, gun shot wounds and fractures about the shoulder joint. From these sources any kind of pyogenic bacteria may enter. Primary infections usually are more destructive to the glands than secondary infections because the glands do not have so much time to form their resistance.

The exciting cause is bacterial, such as the pus forming organisms, tubercle baccilus, baccilus malignant oedema and others.

The tissue changes in glands varies according to the type of infection. Infection with the baccilus malignant oedema may be described as a solid confused indurated mass of vessels, connective and glandular tissue, without much swelling. With the pus forming organisms there are constant changes; gradual swelling and induration of the whole gland and surrounding tissue, with whipcord condition of lymphatic vessels to the gland involved. Cross sections of the glands at first show simple induration, later breaking down into pus and abscess formation. It is when the gland becomes solid from induration that its function of filtering and fighting power over bacteria ceases, and the

danger arises of the enemy bacteria getting through to the next group of glands or into the blood vascular system giving general blood poisoning or constitutional disease.

Symptomatalogy is fairly constant, depending upon the type and virulency of the infection, with temperature, swelling, pain, tenderness of the glands, often chills and general aching. Incubation period varies from a few days after the original site is exposed to infection, to several weeks. The duration depends upon the resistance of the individual, type of bacteria and its virus, and treatment.

By far the most important treatment is preventive; vaccination is probably premature. Training in hygiene, health habits, sterilization of wounds, and how to keep wounds aseptic, are of great assistance in keeping the axillary glands healthy. The active treatment varies with the type of infection. Here we must confine this paper to the simple and pus infections, leaving the tubercular, syphilitic, malignant oedema, tetanus, etc., to special study. The focci of both secondary and primary infections must be well drained and have frequent dressings. Regional skin diseases should have immediate attention. Free catharsis must always be maintained and symptomatic treatment instituted. Administration of autogenous vaccine made from secondary infection focci is often of value. External heat must be applied to the axilla continuously until the infection is aborted or a diagnosis of abscess formation is made. Then surgical treatment of free drainage and sterilization of the wound by the Carrol-Dakin method is usually found most effective.

EDUCATION IN THE THERAPEUTICS OF GRAY MATTER

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The gray matter is anatomically disposed as the cortex of the brain, as several islands within the same and as the medulla of the brain stem and of the spinal cord.

Histologically it is composed of many-poled cells and branched dendritic processes, (arborizations) together with its supporting tissue. Functionally it is the seat of so-called "centers" related both to trophism and to action, mental, special sense and motor.

Lesions of gray matter may be discrete, general, or complicated by those of white matter or of other tissues or organs.

Discrete lesions and their therapy are the subject of discussion in this paper. The discussion is further narrowed to the motor gray matter. Motor gray matter is related in location to trophic substance and is probably related to it in function.

The location of motor gray matter is each side of the fissures of Rolando for a variable area, beneath the ventricle of the medulla oblongata, and in the interior horns of the spinal cord.

The function of motor gray matter is receiving and passing of impulses to the motor tracts of brain and cord and to the peripheral nerves.

Lesions of this substance are treated on the basis of four principles, the specific, the hygienic, the trophic-instinctive and the educational.

If the lesion be specific within the range of known specific remedies, specific treatment is fundamental.

The hygienic treatment has the same importance as in pathologic conditions of other tissues and organs.

The trophic-instinctive belongs to the relatively unconscious and involuntary activities by which all repair is made and the fundamental functions are achieved.

The educational principle has a preponderating application in lesions of motor gray matter when those lesions are end results or residui of pathologic or traumatic processes.

These residui are the most frequent lesions of gray matter.

They group themselves into the cerebral palsies and the spinal palsies. Typical of the former is birth palsy. Here hemorrhage or inflammatory changes have occurred affecting the Rolandic areas with consequent atrophy of gray cells. The functional effects of such lesions are seen in spastic paralyses of skeletal muscles of greater or less extent.

Typical of spinal palsies is anterior polyomyelitis. Here there is toxic atrophy of gray cells in the anterior horns. Functional effects are seen in flaccid paralyses of skeletal muscles.

What recovery can be hoped and how can it be effected?

The usual points of attack are the muscles themselves, and their vascular and nerve supplies.

It is fondly hoped that atrophy can be limited by stimulating the muscles and nerves and mechanically inducing greater vascular activity. It is sometimes thought that by sending the electric current through the neuromuscular system function may be restored. But such effects have never been produced by these means, as the means are no more adapted to the ends sought than the stimulation of an electric light bulb and its contents is adapted to reactivating a damaged motor. Whatever results have been achieved are to be attributed to nature's unaided efforts as seen in hygienic and trophic-instinctive effects.

Gray matter responds directly only to educational efforts. Educational results are characterized by more complex and finely adaptive arrangements and contacts between gray cells through their arborizations. It is in the unhurt but hitherto unused surplus of gray cells that our hope lies.

New paths for the transfer of motor impulses possibly may be found, and new arrangements in cell groups when partial damage has been done may be achieved.

Even though a current of electricity may travel the route of the reflex arc there is only cellular response and not definite and purposeful organic function. Tetany and tremor are not artistic achievement. Causing the muscles to "jump" is not dancing a jig.

Persons with cerebral and spinal lesions of motor gray matter are improved by definite neuromuscular re-education. If massage and electricity and the like have value it is because of general hygienic effects.

In children re-education is carried on by reconstructive play often beyond the limits of that obtained by direct muscle pedagogy. Competitive reconstructive play often carries function to a complete recovery.

Nothing can be manipulated into gray motor matter except the damage of fatigue. Much may be developed out of motor gray matter in proportion to the unhurt residue and skill of the pedagogue.

DISCUSSION ON DR. EAST'S PAPER

Dr. Pollock said, "I had in the last ten days an experience which illustrated nicely Dr. East's reference to involvement of the Rolandic area during child birth. This was a tedious and difficult labor—culminating by forceps. This child's face on one side was involved—spastic contractions of hand and arm which had almost cleared up in ten days, showing the tendency to recover by being left to nature."

A STUDY OF ACIDITY CURVES IN STOMACH CONTENTS

FRANCIS M. THURMON
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The paper by Francis Thurmon, a student of Illinois College, Jacksonville, Ill., was introduced by Professor Isabel S. Smith of Illinois College, as follows:

Illinois College has a department of biology, and I who have the honor of occupying that settee am a botanist. We have, of course, men who are preparing for medicine. Through the kindness and under the direction of Dr. Frank Garm Norbury of the Norbury Sanatoriums, we are able in the excellent laboratories of those institutions to furnish our strongest prospective medical students a chance to do what is to them research in the latter part of their college course. Dr. Norbury is a loyal alumnus of Illinois College, has an A. M. from the University of Illinois, is a graduate of the Harvard Medical School, and while there was an assistant in the pathological laboratory. Before taking work with him these men have taken in Illinois College a year of zoology, invertebrate and vertebrate, a semester of histology, a semester of vertebrate embryology and two or three years of chemistry.

Besides the work which Mr. Thurmon will present, individual students are doing work on myleogenous leukemia, on anthrax isolated from a clinical case, studied by means of guinea pig cultures; on histological preparations from a case of sphlenic anaemia, the spleen having been removed at time of operation; on cancer of the oesophagus and inflammation of the spinal cord, removed at autopsies. Blood chemistry is often introduced.

I cannot tell you what an inspiration this is to these advanced zoology students. Thinking that this may be of assistance to other professors in small colleges, I have

asked Mr. Thurmon to present a piece of work done under Dr. Norbury's direction, "A Study of Acidity Curves in Stomach Contents." The Paper follows:

The method of gastric analysis clinically in vogue at present entails the feeding at a standard test meal, the partial removal of stomach contents at fifteen minute intervals over a period of 90-120 minutes, and the examination of the samples for: (1) Total acidity, (2) Free acidity, (3) Lactic acid, (4) Occult blood, (5) Bile, (6) Microscopical constituents.

OLD METHOD

The old method used until the introduction of the Rehfuss method of fractional analysis consisted of feeding of a standard test meal, the partial removal of complete stomach contents at the end of a one-hour period, and the analysis of the material so removed. That this was inaccurate has been proved through laboratory examination and is best explained by graphic representation.

Owing to the bulk of the stomach tube and the marked discomfort occasioned by its use, it was impossible to follow the complete cycle of digestion and to estimate the different changes step by step which took place in the stomach after the introduction of a definite stimulus such as various foods. At the end of one hour the entire stomach content was removed and examined. Chart 2 will suffice to show the fallacy of this method. Both curves represent the total acidity of two different cases. They show a vast variance by the fractional method; but by the old method, which called for the removal of complete stomach content at the end of one hour, one would readily suppose they were normal curves.

REHFUSS TUBE METHOD

Realizing the inadequacy of the procedure entailed in the old method, Dr. Martin E. Rehfuss devised an apparatus and procedure by which it is possible to follow the entire cycle of digestion without undue discomfort to the patient. It is the so-called "fractional method." The modified stomach tube (No. 12 French Tubing) is fitted with a metal tip. The tip is slotted with large perfora-

tions, the diameter of each being equivalent to the maximum bore of the tubing. The principle of the tube is entirely that of gravity, and the tip is sufficiently heavy to seek the lowest portion of the stomach. The instrument is inserted and left in the stomach for hours until the gastric cycle is completed. It is possible at any given moment to draw off any or all of the juice secreted in sufficient quantity to perform the necessary chemical examination.

METHOD

The patient is requested to drink no water at any time after the evening meal on the night previous to examination, and to eat nothing until after the test is complete. Usually he presents himself about 8 o'clock the following morning for removal of residium by means of the Rehfuss tube.

REMOVAL OF RESIDIUM

The swallowing of the tube may be accomplished without the aid of water. In obstinate cases where swallowing is difficult the process may be accomplished by coating the tube and tip with a thin film of petrolatum, and by placing the tip in the lower part of the pharynx, back of the tongue, and having the patient swallow. When the tube has reached the stomach (which has been determined by measurement) the contents are aspirated. A normal residium of large volume possessing a total acidity value of seventy or over may indicate ulcer.

THE TEST MEAL

Before making an analysis of stomach contents it is customary to introduce something into the stomach which will stimulate the gastric cells. The response to this stimulation is then measured clinically by the determination of total and free acidity in the stomach contents. The test meal most widely employed is the Ewald test meal, which consists of 2 pieces (35 grams) of toast and 8 ounces of tea or water. (The water meal is advised because it has the added advantage of enabling one to determine the presence of food rests, and to test more accurately for blood and bile.)

THE RETENTION MEAL

In order to obtain more information, if desired, regarding gastric motility than is furnished by the ordinary test meal, the patient may be fed a so-called retention meal. This meal is fed in place of the customary evening meal and contains substances readily detected. In the morning before breakfast the stomach contents are removed and examined for food rests. A normal stomach should give no evidence of food retention. A satisfactory retention meal consists of six raisins.

REMOVAL OF SAMPLES FOR ANALYSIS

At exactly fifteen minute intervals from the time the test meal is eaten until the stomach is empty, 10 c. c. samples of gastric contents are withdrawn from the stomach by means of aspiration.

EXAMINATION OF SAMPLES

The modern tendency among clinicians is to lay particular emphasis upon the value of free acidity and total acidity. The determination of presence or absence of occult blood, mucus, and food rests are also of importance. Microscopic examination may show remnants of food from previous meals, red blood corpuscles, pus cells, sarcinae, excessive number of yeast cells, bacteria, and definite abnormal cells in an abnormal ulcerating cancer, all of which are of diagnostic importance.

DETERMINATION OF FREE HYDROCHLORIC ACID

Principle—The indicator used is di-methyl-amino-azobenzene (Toeopfer's reagent.)

Procedure—Measure 10 c. c. of the gastric contents and introduce it into a clean 100 c. c. beaker. Add 2 drops of Toeopfer's reagent, and if free hydrochloric is present the solution will turn a visible pink (depth of color depending upon acid concentration.) Titrate with N/10 sodium hydroxide until the red color is replaced by an orange yellow. Take the burette reading and calculate for free acidity.

Calculation—The indicator used reacts only with free hydrochloric acid, hence the number of cubic centimeters of N/10 sodium hydroxide used indicates the volume necessary to neutralize the free hydrochloric acid of 10 c. c. of gastric juice. To determine the data for 100 c. c. of gastric juice multiply by 10. Occasionally in the fractional method it is not possible to obtain 10 c. c. of a specimen in one or more of the periods of aspiration. In this case use 5 c. c. of the gastric content and dilute to 10 c. c. with distilled water and proceed as above. Multiply the results by 2 because a 5 c. c. dilution was used. The latter procedure gives only approximate results, yet, an idea of the nature of the curve is determined.

TOTAL ACIDITY

Principle—The indicator used is phenolphthalein. Since the indicator reacts with mineral acids, organic acids, combined acids, and acid salts, the values obtained represent the total acidity of the solution.

Procedure—To the titrated solution used above add 2 drops of phenolphthalein and titrate with N/10 sodium hydroxide until a faint pink color is obtained and persists for about two minutes. Take the burette reading and calculate for total acidity.

Calculation—The number of cubic centimeters of N/10 sodium hydroxide used indicates the volume necessary to neutralize the total acidity of 10 c. c. of the solution. To determine the data necessary for 100 c. c. multiply by 10. (It is customary to express the acidity in values per 100 c. c.) This product of acidity represents the total acidity of 100 c. c. of the solution of that period.

OCCULT BLOOD

Guaiac method used: Introduce 1 c. c. of gastric contents into a 10 c. c. test tube and acidify with 1 or 2 drops of glacial acetic acid. From a previously prepared solution, consisting of a few Guaiac crystals and 95% alcohol (about 6 c. c. vol.), add to the gastric contents in equal

volume. To this add a similar amount of hydrogen peroxide and if chemic blood is present the solution will turn a distinct blue.

TYPES OF CURVES

Curves representing total acidity and free acidity of the periods during complete cycles of digestion have been made. The ordinate of the graph represents the degree of acidity and the abscissa of the graph represents the time periods.

1. Isosecretory type shows a steady rise, high point usually sustained for half an hour and then a gradual decline. The curve is usually steady and unbroken; its high point rounded and not abrupt and is to be found within the neighborhood of one hour. Chart No. 1.

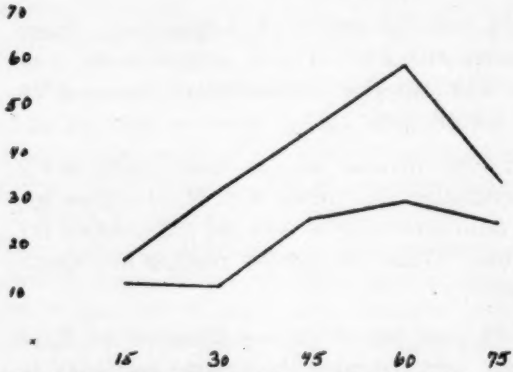


Chart 1.— Isosecretory type. Top line represents total acidity and lower line free acidity.

2. Hypersecretory type shows a rapid response to stimuli, rapid increase in acidity, high point from 70 to 100 or over, either abrupt or sustained, and a slow decline or none at all in the usual time. It is called the hypersecretory type because of the general tendency to assume exaggerated proportions. Chart No. 3.

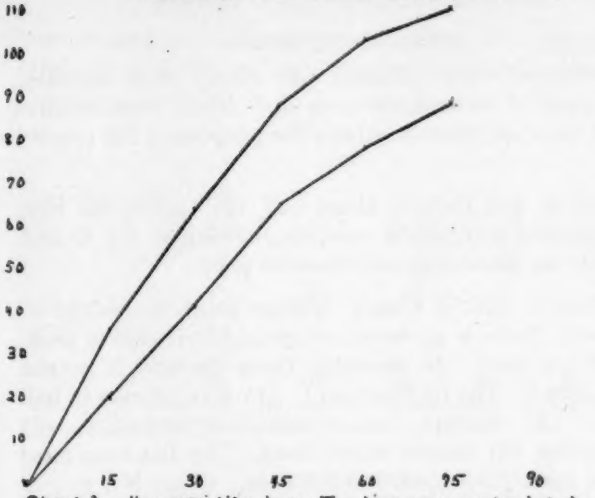


Chart 3. Hyperacidity type. Top line represents total acidity and lower line shows free acidity

Curves 1 and 2 are typical of the reaction of normal individuals when given an Ewald meal. A consideration of these curves from the examination of normal individuals indicates that there is no normal curve which will hold for all cases, but a normal curve may vary within certain well defined limits.

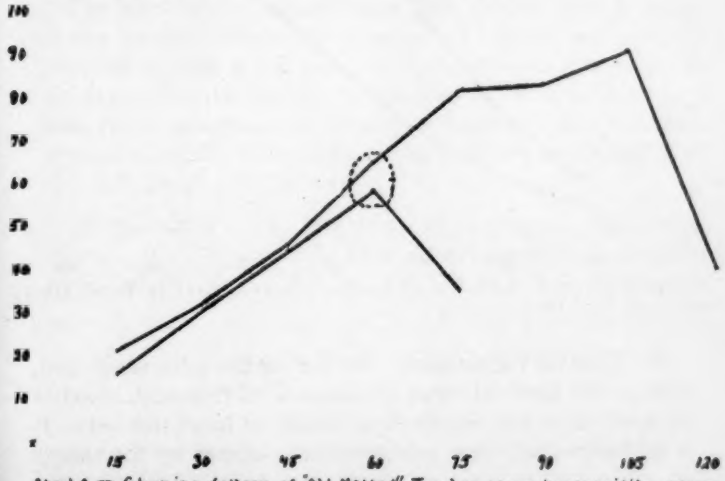


Chart 4.— Showing fallacy of "Old Method". Top line shows hyperacidity after the one hour period. Lower line represents a normal curve.

PATHOLOGICAL CURVES

Pathologically any variation may occur, each variation type typical of its stomach disorder. But a consideration of their interpretation is outside the purpose of the present paper.

Charts of (1) Gastric ulcer, and (2) Carcinoma have been prepared with slight analysis showing as far as possible how the laboratory examination goes.

1. Case of Gastric Ulcer: Tender point, persistent occult blood. There is an excess of hydrochloric acid in about one-half the cases. In the other cases the acid is normal or diminished. The findings are: (1) a rapid rise in half an hour, (2) distinct, rather abrupt hyperacidity, (3) rapid decline, (4) usually occult blood. The diagnosis must be based largely upon clinical evidence. Chart No. 4

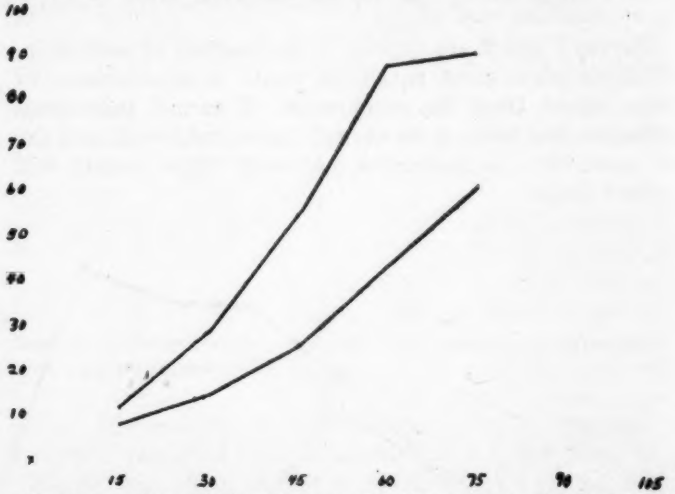


Chart 4 — Case of Gastric Ulcer: Top line representing total acidity and lower line free acidity

2. Case of Carcinoma: As far as the laboratory findings go the cardinal signs are absence of free acid, blood in all specimens, and Oppler-Boas bacilli in large numbers. It is probable that some substance is produced by the cancer

which neutralizes the free acid. Also carcinoma seems to furnish a favorable medium for growth of Oppler-Boas bacilli. Chart No. 5.

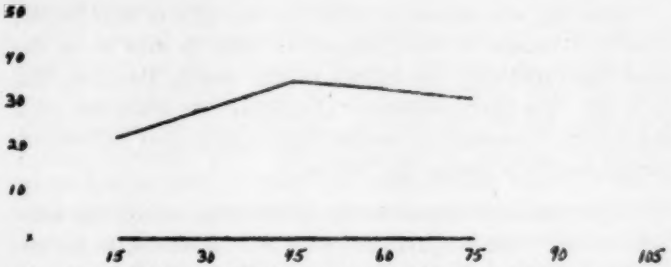


Chart 5.— Case of Carcinoma: showing free acidity equating zero (lower line.), and low total acidity (top line).

CONCLUSION

1. Gastric juice in healthy normal individuals shows no specific curve, but types of curve can be found which are named isosecretory and hypersecretory.

2. The pathological significance arises when a curve shows any marked deviation from the recognized standard.

The most typical curves have been chosen from a group of one hundred fifteen cases examined. It has not been my purpose to offer a complete interpretation in this study of acidity curves, so much as it has been my aim to show how they serve as a means of aiding in diagnosis, and to represent some of the possibilities open for advanced study during a "Liberal Arts Course."

Bibliography: (1) Practical Physiological Chemistry. Hawk. (2) The Journal of the American Medical Association, Vol. 63, Nos. 1, 2. Vol. 64, No. 21. Vol. 65, No. 12.

PRACTICAL INFANT CONSERVATION

M. D. POLLOCK, M. D., DECATUR, ILL.

I have but one excuse to offer for the title of this paper, namely, I happen to be a citizen of what is said to be the most healthful city for babies in the world, Decatur, Ill., U. S. A. We have succeeded in raising her from the mud and malarial swamps of earlier days, and placed her on the world's health pinnacle for babies.

The recent Red Cross Survey of Decatur, under the auspices of the State Department of Public Welfare, in its report, makes the following statement relative to infant mortality:

"Sir Arthur Newlsholme, the eminent English authority on infant health, has written that 'Infant mortality is the most sensative index we possess of social welfare and of sanitary administration, especially under urban conditions.' The Decatur figures show it to be very progressive in the reduction of infant deaths."

"During the fiscal year 1918-1919, 918 babies were born in Decatur; 35 babies were reported to have died during the first year of life, giving a rate of 38.19 per one thousand births."

Assuming that births and deaths are well reported and this rate therefore correct, Decatur has reason to take pride in this remarkably low rate. It is considerably lower than for any city reported for the Federal census area, and lower than New Zealand, which ranks lowest of the countries of the world that report these figures.

The Federal Census for the 23 states in the registration area reported in 1911 an infant mortality rate of 124 per thousand live births, and in 1915 for a smaller area, it showed a rate which varied from 70 to 120. Cities of 25,000 population or over ranged from 54 in Brookline, Mass. to 196 in Shenandoah, Pa. New Zealand has reduced its rate to 51.

During the same time the city's birth rate, 20.9 per 1000 population, shows a fairly healthy and normal increase. In the U. S. registration area in 1917, it was 24.6 per 1000 population.

The annual report of the Commissioner of Public Health and Safety of the City of Decatur for the year ending April 30, 1920, gives even a lower mortality rate for children under one year of age, as follows: Total number of births reported 888. Total number of deaths 31—which gives a mortality of 34.9 per 1000 babies born. This includes only the corporate city and will not tally with the report of the State Bureau of Vital Statistics which report is not confined strictly to the corporate boundaries of the city.

Anticipating your first inquiry, "How did you do it?", I will state to begin with that personally I have nothing new or startling to offer. In the ten minutes allotted to me I only hope to review as of a landscape in an aeroplane flight, a few of the things Decatur did in establishing this record on a mere 18 cents per capital allotted to it for health, a record which I am sure you will grant is worthy of the title of this paper, "Practical Infant Conservation."

In order to analyze all the factors entering into the health of any community, one will necessarily have to go back a generation or two. I can only mention some of these factors at this time.

1—Our people have inherited the rugged health of the pioneer, which is an asset not to be overlooked.

2—Our varied climate tends to raise the resistance of the body against outside influences. (I do not accept the popular impression that we have a bad climate.)

3—We have converted our once germ breeding swamps and stagnant pools, by means of the dredge and tile, into running streams, flanked by verdant pastures, and fields of fragrant clover and waving grain.

4—Thus we have made it possible to raise agriculture, horticulture and animal industry to the highest possible standard, which in turn is an important factor in our milk

and food supply, which has so much to do with the standard of health. It would have been impossible to attain distinction as a health center if our streets had remained a quagmire, and Lincoln Square a hog wallow.

5—Coming down to our present city, in attempting to lay a finger on the things which have contributed to its health, and more especially to the health of the child, one becomes bewildered with the multitude of things, which though playing only an infinitesimal part, might have turned the balance against us.

I would put *first* and at the top of the list, without which it would be useless for any city to hope to attain distinction either in raising babies, or selling municipal water bonds, CIVIC AND COMMUNITY SPIRIT. I consider this so *fundamental and important* that I am almost tempted to stop right here that you might have this first essential riveted to your memory.

The paragraph just read is the important part of my message; the details can be worked out by any community backed by the above spirit. This, I think, is the real secret of Decatur's record. I fully recognize however that excellent work had to be done by the various organizations, city officials and many individuals, a few of which I wish to mention after enumerating the Machinery operating for better health in Decatur and Macon County, as tabulated by the Red Cross Survey.

Private physicians in Decatur, 75-80.

Private physicians outside Decatur, 17.

Decatur Medical Association.

Graduate nurses in city and county, 80.

County physician.

City Department of Public Health and Safety.

Commissioner.

Director of Public Health (Physician resigned May 1, 1920.)

Assistant Health Officer.

Sanitary Officer.

Milk Inspector.

Superintendent of Child Welfare.
Building Inspector.
City Scavenger.
Police Matron (part time.)
Assistant Police Matron (part time.)
Decatur and Macon County Hospital.
St. Mary's Hospital.
Wabash Hospital.
Social Hygiene Clinic.
Tuberculosis Clinic.
Crippled Children's clinic.
3 clinics for school children.
Mental clinic under State Hospital.
Mental test by teacher of room for subnormals.
School nurse in city.
School and Visiting nurse in County.
Macon County anti T. B. and Visiting Nurse Assn.
Y. W. C. A. Health Center.
Hospital Aid Association.
Junior Sanitation League.
Red Cross and V. N. A. classes in Home Care of the Sick and First aid.
Health exhibits and posters in schools and educational work through Associations and clinics.

2—A Commissioner of Public Health and Safety. Under his supervision the Junior Sanitary League of 300 boys did a wonderful piece of work by making two house to house sanitary surveys of the city during the year with a detailed report. This not only assisted greatly in locating ill kept back yards, cess pools and privy vaults, but was of even greater educational value in creating a pride and a real competitive desire to excel, among our citizens.

3—A practical competent Director of Public Health, or all time health officer, who directed the various health activities and kept them working in harmony, seeing that one did not overlap the other unnecessarily. Among these

were running down communicable diseases, placing temporary quarantine on contacts, detecting chronic carriers, making tests to ascertain who were immune and those who were not, and a multitude of things which can only be done by one especially trained.

4—The branch of the health department in my opinion having *most* to do directly with lowering infant mortality in Decatur, was the Child's Welfare Department. The Slogan of this department has been "Keep the Well Baby Well." Under this department were maintained infant welfare stations, where 329 babies were registered and more than 800 examinations were made, the mother given advice as to the care of the baby, the food best for it, and other educational work. A remarkable feature of the work was the fact that not a single child attending the clinics died during the year. Number of nursing and instruction visits in homes 1097. Number of advisory calls 420.

This organization has for its head the Medical director, and is directly under the supervision of the Child's Welfare Nurse. The Federation of Mothers' Clubs co-operates, thus making it widely educational. "Educate, educate, educate," should be the slogan.

The Day Nursery has cared daily for an average of 30 children whose mothers were working, and has provided for others who came in after school hours. It also maintained a free kindergarten for these children. The matron visits all homes in sickness or trouble.

5—Scarcely second to the Child's Welfare Department is the Dairy Inspector, for pure milk is essential to healthy bottle fed babies. Our dairy inspector is especially adapted to his work, being a practical dairyman himself and personally acquainted with every dairy in the community, and he takes pride in being able to direct physicians or others just where to obtain the desired milk supply. He has really induced a sort of competitive rivalry among the dairymen to produce the best baby milk possible.

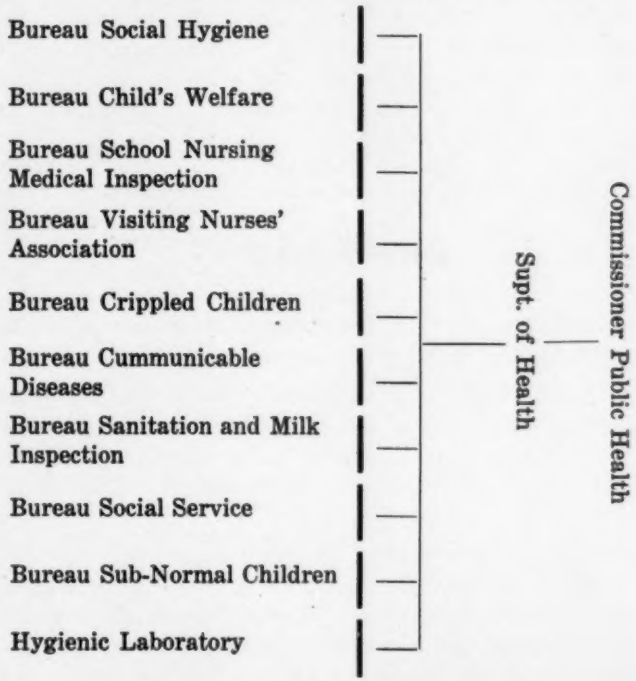
6—The Venereal Clinic has undoubtedly contributed its share in lowering infant mortality. During the year four

syphilitic pregnant mothers were treated, with no mortality resulting among the babies born of these mothers. Without treatment we would naturally expect a very high mortality.

In conclusion I wish to submit a diagram for affiliating health activities as outlined by Dr. I. H. Neece, Decatur's recent Health Director.

DIAGRAM

Plan for Affiliating Health Activities for Year, 1920



DISCUSSION OF DR. POLLOCK'S PAPER

Dr. East added that the excellent status of Public Health Administration in Decatur, especially as it related to infant welfare, is almost purely the result of local initiative and serves to clearly demonstrate what can be done along these lines elsewhere. Dr. Pollock closed the discussion by

giving a digest of the work of the local junior sanitary league, and referred to the importance of a full time municipal health officer. The last point has also been demonstrated in Decatur by an experience of two years and the late removal of the health officer for economical reasons.

Papers on Physics

SOME PRACTICAL PROJECTS IN TEACHING PHYSICS

PROF. C. F. PHIPPS,
NORTHERN ILLINOIS STATE TEACHERS COLLEGE,
DEKALB, ILL.

Physics deals with so many things connected with our home, school and community life, that if it is presented in a practical, rather than the usual cut-and-dried way, it is both interesting and instructive to our youth. Half a century ago there were fewer inventions and up to date conveniences, so the people of both city and farm were able to become acquainted with the limited number of things belonging to the field of science. The few conveniences then were learned easily at home, and the people were relatively more efficient than now. But inventions during the last half century have multiplied so rapidly that the home has been unable to keep up with them, so that the burden of making our youth efficient has fallen more and more upon our schools and colleges. These institutions as a whole are failing in much of this efficiency work.

Listen to some of the adverse criticisms of science teaching that are offered: "School work, especially in science, is too artificial—not real." "Most of the science subject-matter taught remains unused, both in and out of school and college hours and in after school years." "The big problem of the school is that there is very little relationship between the work of the school and the work ot the world." "Our physics books are too much on the order of encyclopedias or dictionaries, and their proper function is for reference only." "We lack books for high school and college which present science as living projects." "The basic error in science teaching today is that it does not center itself about the interests and desires of the students."

One of the professors in Columbia Teachers College asks and answers this question: "Why do we, as mature people, go to the literature of the automobile company to learn about the workings and methods of repairing of our batteries, and to make other repairs, rather than to a physics

text book? Simply because the company's literature satisfies us, and explains in a practical, instructional way the workings of the battery and other parts, and touches closely and appealingly to the project we have." "We must remember," he adds, "that students are immature men and women and do not enjoy studying dry, unrelated facts, principles, theories and fundamentals any more than we would."

Why not bring small samples of real life and real workable problems to the school and college more than we do, and give them as projects—those which will appeal to and grip the student? This will not only interest them and show the worthiness of physics, but it will develop their thinking power. Dewey says that "there is no thinking without a problem. When judgment is challenged to face a dilemma it makes a fork in the road and thinking begins here."

I grant you that there are difficulties in the way of teaching by the project method, such as large classes, lack of suitable projects, the time factor in the teacher's and student's busy life, lack of trained teachers, lack of equipment and supplies, etc. Yet many science teachers in high school, normal school and college are doing work of this kind, and our plea now is for many more teachers to tackle the problem and thus give students worthwhile opportunities of studying science in practical ways.

Since time for this paper is so limited, I will confine myself to one phase of work in physics, namely, some practical projects in electricity. A few years ago while teaching a small class of high school boys we took up some projects in electric wiring. Several small, roughly boarded rooms in the manual training department served our purpose. Only three sides and ceiling were boarded, leaving the front of each room open. In these rooms the students worked out in detail a number of projects in electric wiring of homes, such as door bells, call bells and lighting. The interest was keen, thinking was stimulated, and the results educationally were good, even though not all of the

individual work was neat and perfect. At other times practical electric burglar alarms for windows were worked out and some students installed them in their homes.

Electric dry cells are easily made, though they may be weaker than boughten ones, by taking apart old dry cells and using the zinc container and carbon stick, and packing a new pasty mixture of chemicals around the carbon rod in this container. This gives the student an intimate knowledge of the construction of such cells. A strong wet cell, which students enjoy making and using, can be constructed with a cup of water in an eight ounce bottle, a teaspoonful of potassium bichromate and a tablespoonful of sulphuric acid. Carbon and zinc rods, with wire attached, complete the cell.

With such cells a usuable medical battery, or shock coil, can be constructed, using a simple switch, a buzzer for make and break, and two pieces of coiled metal attached to wires to hold in the hands.

A miniature home lighting system is a good project. It is made by mounting several sets of lamp sockets on short boards, each set representing a separate circuit in the house, and these all connected to the main line with switch and fuse plugs. If a watt-hour-meter is at hand the cost of using each lamp or circuit may be ascertained by the students.

Again, the students may mount more lamp sockets on a board, having adjustable connections or switches between them so that the sockets may be cut out or cut in at will, and thus a handy lamp-bank is ready for a number of experiments.

Since students occasionally burn out valuable instruments by using wrong connections, they ought to equip themselves with a small fool-proof switchboard which tells at once whether their connections are right or wrong. Having learned the right connections to make with this small switchboard, practically all danger of burning out valuable instruments is avoided.

After electromagnets have been made and tested our students have put them to practical use by making simple tele-

graph sets and sending messages to each other, either in the laboratory or by installing the sets in their homes.

The making of induction coils, spark coils and other parts of wireless outfits are good projects. Not only do students of physics make most of their wireless apparatus, but boys who never have had physics are doing it. I feel sure that anyone present can relate instances of keen interest shown by students when allowed to make, or assist in installing, a wireless in the school, or when making their own outfit at home.

To mention briefly a few other practical projects in this branch of physics, I will suggest that the electroplating project, such as copper plating and nickel plating, be given. Let the students assemble the apparatus and actually plate things. Electrolytes and ionization are taught much more easily after a first-hand acquaintance with electroplating. Different solutions made with distilled water, using in turn salt, acid, sugar and glycerine, may be tested for conducting power, thus showing ionizing and non-ionizing substances.

Why not begin the study of the storage battery by having the students construct simple ones with pieces of lead, a pint fruit jar and dilute sulphuric acid? After charging and testing this storage cell by ringing bells, the construction and workings of the regular battery will be understood more easily.

Interest and profit are gained by having students make Geissler tubes out of old electric light bulbs. The glowing, rarefied gas in such bulbs stimulates interest in another line, and may well lead to the mysteries of X-Ray production.

Making arc lights, using home-made electromagnets to draw the carbon sticks apart when the current is turned on, teaches the principles involved in street lights and lights used in stereopticon lanterns.

Continuing from this the electric furnace may be constructed, using electric light carbons enclosed in hollowed out fire brick, or in a box lined with some refractory material.

Recently our students obtained some wire of high resistance and worked out a number of interesting projects. One was an electric heater, capable of heating a small room. A piece of sheet aluminum was cut and shaped into a reflector, and the heating wire, wound around an asbestos covered porcelain tube, was mounted in front of the reflector. Some more of the same wire, mounted in six separate coils in the bottom of an asbestos lined shallow box with metal top, made a serviceable heater that could be used as a foot-warmer, or moderately hot stove or toaster. One student wished to make an electric flat iron. He did so by using some of this resisting heating wire inclosed between suitably insulated pieces of lead for weight. He covered it all with sheet copper, and fastened on a wooden handle. When connected to a 110 volt circuit it worked well. Surely college and high school students are interested and benefited in doing such practical work.

A little more ingenuity is required for making a Tesla Transformer which will give a 6 to 8 inch spark, but our students have done it after having had an introductory course in electricity.

When other projects are scarce a little time may be spent profitably in making blue print paper and then taking permanent pictures of magnetic fields about magnets and about current bearing wires. Also simple detecting galvanoscopes, electroscopes and electrophorouses may be made by students and experiments performed by using them in preference to elaborate and expensive apparatus.

I will mention in closing one other example of project work, and that is in the field of repair work. When some apparatus is out of order, if it is not too delicate and complicated, we give it to capable students to repair. They enjoy such work and often get much out of it, since they must learn how the apparatus is constructed and the principles by which it works. To mention a concrete case—we have an electric washing machine in our laboratory for demonstrating one use of the motor, and some time ago it failed to work properly. Some students took the motor off the machine, dissected it and found that a loose screw had caused a short circuit and partly burned out the armature.

Since we have not the facilities as yet for winding motors, we had the armature repaired at the factory; then the students assembled and installed it on the washing machine, making the rather difficult adjustments with ratchets, and the satisfaction of putting the whole machine in good working order again was worth while.

I am sure that you can suggest many more practical and instructive projects for students to do in the wide domain of physics, both in elementary and advanced work, and you who have done some of this kind of teaching know how it enriches a course, and makes the student exclaim "That was the best science course I ever took. I got lots out of it."

DETERMINATION OF THE VAPOR PRESSURE OF MERCURY BY MEANS OF THE KNUDSEN PRESSURE GAUGE

PROF. C. F. HILL, UNIVERSITY OF ILLINOIS

While engaged in experimental work in the spring of 1920, the question arose as to the pressure of saturated mercury vapor. Upon looking in the tables for the values at temperatures ranging from 0° to 20°C., it was noticed that there is little or no agreement between different observers. Data for but three direct methods was found listed at the above temperatures. An accurate knowledge of the vapor pressure of mercury is important in vacuum work since mercury is almost always involved in the vacuum in some way, either in gauges or pumps. Due to this fact, and to the lack of agreement of former observers, and also to the small amount of data really taken before, it was decided to try to devise a more dependable method. To this end a Knudsen pressure gauge was used. This instrument is independent of the gas used and gives accurate readings on pressures of the order of those of mercury vapor at ordinary working temperatures. The calibration of the instrument was accomplished by connecting the apparatus as shown in the Fig. 1. All vapors were removed from the Knudsen gauge side and kept out by

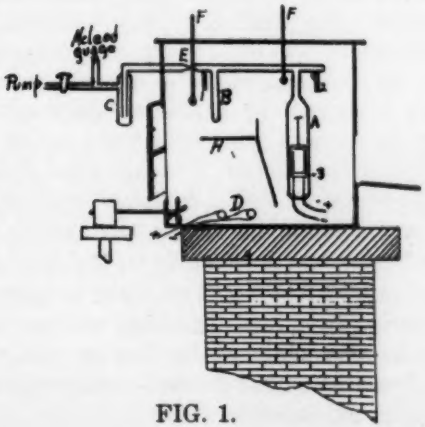


FIG. 1.

means of a liquid air trap. The pressure was then varied in the apparatus and simultaneous readings were taken on a standard McLeod gauge and the Knudsen gauge. A calibration curve was drawn on a large scale from the data thus obtained. This is made possible since the deflection at zero pressure is zero, and the origin thus became an accurate point of the curve. Mercury vapor of course still existed in the McLeod gauge; this, however, had no effect since this instrument does not read small vapor pressures. The Knudsen gauge consists of a platinum strip rigidly mounted within the bulb of the gauge and it is heated by means of an electric current. A light vane is freely suspended in front of the platinum strip. The bombardment of the molecules thrown off from the hot foil causes the vane to turn. The instrument may be used for pressures where the mean free path of the molecules is greater than the distance between the vane and foil. Since this condition obtains only when the vacuum is high, it follows that the Knudsen gauge is therefore adapted for the measurement of exceedingly high vacua only. It has been used in measuring pressures as low as 10-8 mm. of mercury.

Having calibrated the gauge the mercury sample was introduced into the container, B, and purified by repeated distillations in the vacuum. Later on one sample was also treated with nitric acid before being used. The tube was then heated to a temperature of 250° to 300°C for several hours, while the sample of mercury was protected by warm water in a vacuum flask placed on the container. A Langmuir pump supported by a Gaede rotary outfit kept the vacuum at the highest point during the period of heating. All vapors were thus driven from the glass and a residual air pressure as low as .00002 mm. was obtained. The tube was then sealed off at E. The whole system was rigidly fastened within a box in order to control the temperature, and the box in turn was placed on a pier to prevent jarring. A fan properly placed kept the temperature uniform. Low temperatures were obtained by cooling the room, while heating coils placed within the box were employed in maintaining higher temperatures.

After allowing the system to reach a constant temperature for a time, the deflection of the gauge was taken and the total pressure read from the calibration curves. The mercury vapor was then driven into the sample container and held there by liquid air, after which the residual gas pressure was measured as above. The difference of the two readings gave the vapor pressure of mercury at that temperature. Four separate sets of readings were taken, using nineteen temperatures ranging between—7° and 34.9°C. All of the values are within about 6% of a mean curve, which is estimated as the accuracy that is attainable by this method. (See Fig. 2.)

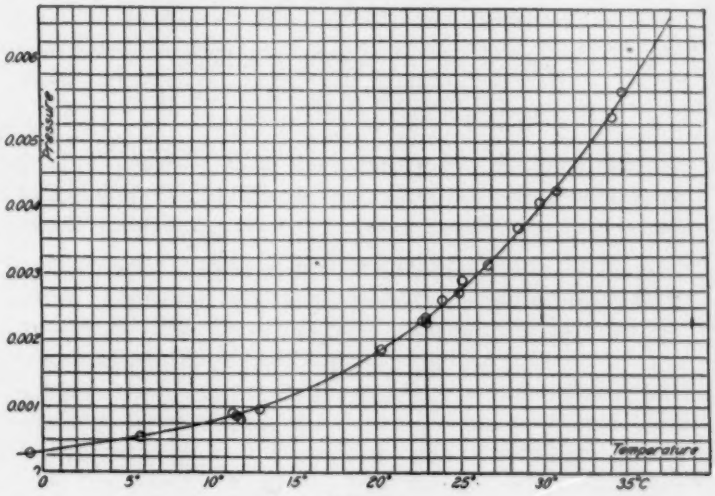


FIG 2.

The data obtained agrees fairly well with that of Morley, van der Plaatz, and with the extrapolated values from higher temperatures by Ramsey and Young. The percent variation in the actual readings is much less in the present method. Measurements by Knudsen, in 1909, give results only 1/3 to 1/2 of those of the three methods mentioned above. His method, however, would be expected to give values too low, and it is not probable that either of the above methods would be in error as much as Knudsen's results indicate. A detailed study of all of the methods seems

to indicate that the value of the vapor pressure of mercury over a range in temperature from 0° to 40°C is near that of the results given by Morley, van der Plaatz, and by the present method, and from the standpoint of accuracy of observations, the present values obtained by the present method should be the more accurate.

The mean values of mercury vapor pressure as read from the mean curve at 10° intervals are:

0°	.00035 mm.
10°	.000775
20°	.00182
30°	.00407
40°	.008

Physics Laboratory, University of Illinois
April, 1921.

THERMAL CONDUCTIVITY OF CONCRETE

PROF. A. P. CARMAN AND R. A. NELSON
UNIVERSITY OF ILLINOIS

The cylinder method was used. A long cylinder had a circular hole along the axis in which there was an electric heating coil. By preliminary tests it was shown that the flow of heat in the middle of the cylinder was radial. The heat generated in the coil in this middle part could be calculated directly from the electric current and e. m. f. per unit length of the coil. The temperature gradient was measured by thermocouples which were placed in holes parallel to the axis at different distances from the axis. The thermal conductivity was then calculated from the formula

$$K = \frac{Q}{2\pi L (T_1 - T_2)} \log \left(\frac{R_2}{R_1}\right)$$

In this formula, Q is the quantity of heat generated in unit length at the middle, t_1 and t_2 are temperatures at radial distances r_1 and r_2 when a steady flow is reached.

Over fifty cylinders of various standard concrete mixtures have been tested at temperatures ranging from 50°C to 300°C. The cylinders were made of various standard concrete mixtures, the ratios of the mixture to the aggregate being 1:2, 1:3, 1:4, 1:5, 1:7, 1;9, and different proportions of the mixing water were also used. The thermal conductivity in c. g. s. physical units for "neat" cement was found to be .00147 and that for mixtures of different aggregates was about .00344 to .00384. The thermal conductivity of "neat" cement is thus about 1/2 of that for any concrete mixture. The thermal conductivity of concrete mixtures did not vary much with the richness in cement of the mixtures.

The above values are for temperatures ranging from 100°C to 200°C, but the effect of temperatures on thermal conductivity below 300°C was not marked. All the above concretes were thoroughly dried and had an age of from 28 days to 120 days.

These experiments are to be described in detail in a bulletin of the Engineering Experiment Station of the University of Illinois.

Laboratory of Physics
University of Illinois
March, 1921.

ACOUSTICAL DESIGN IN BUILDINGS

F. R. WATSON

PROFESSOR OF EXPERIMENTAL PHYSICS,
UNIVERSITY OF ILLINOIS

Acoustical defects in buildings are forced on the attention of the public in a considerable number of instances. These defects are sometimes found in auditoriums where speaking or music, or both, are heard at a disadvantage, or again in rooms where sounds from other parts of the building become noticeable in an objectionable way.

The usual cause of the defects in an auditorium is found in the hard, non-porous walls of the room which reflect a large percentage of the incident sound with a consequent small absorption of the sound energy. This results in an undue prolongation so that successive sounds, as in speaking, are thus thrown in competition with each other and a listener has difficulty in following the sequence of a speech. This prolongation of the sound, or reverberation as it is called, may be corrected or avoided by having a suitable amount of sound absorbing material in the room. For music, the defect is not so objectionable, because musical sounds can overlap and yet be acceptable for most cases.

These principles may be illustrated by describing two auditoriums recently built at the University of Illinois which incorporated acoustical features designed by the writer in co-operation with the architects. In both auditoriums, the acoustical specifications were detailed in the plans before the rooms were constructed.

One auditorium is the Concert Hall of the Smith Music Building, for which Professor James M. White was architect with Mr. George E. Wright as associate architect. In this case it was desired to have a room with qualities that would co-ordinate as far as possible in the acceptable production of music. For this purpose, as shown by the theory of the subject and illustrated in the cases of auditoriums already built and found suitable for music, the room was designed with a moderate amount of absorbing material so that the reverberation would be somewhat pro-

longed. The walls were to be quite reflecting, with ventilators at critical positions to avoid echoes and undue reverberation. The absorbing material was located largely in the seats which were to have considerable upholstery. The results obtained are in accordance with the predictions. One performer stated: "It is easy to sing in the Hall—the notes flow freely and the voice can be used almost without effort." Instrumental music—that is, chamber music of moderate intensity—is also rendered so as to produce a pleasing effect. A maximum audience reduces the reverberation somewhat without detriment to the acoustics. The room is not suited for heavy music of great intensity, since this would be rather overpowering. Neither is it well suited for speaking because of the relatively long period of reverberation.

The other auditorium to be described is located in the Wesley Foundation Social Building. This room was to be used primarily for speaking; therefore, the acoustical design was quite different from the Concert Room of the Music Building. The period of reverberation should be short in order that a spoken word after making its impression should die out quickly. As in the preceding case, here too, the theory of the subject with illustrative halls gave suitable guidance for the acoustical prescription. It was recommended that the ceiling walls of the room, which formed an inverted V, should be covered with a sound absorber—a pulp board in this case—that could be easily installed and which presented an acceptable appearance. Calculations showed that this material would give a reverberation acceptable for speaking for a room with the volume of the Wesley Auditorium. The outcome confirms the prediction. Speaking is heard distinctly even when only several people are present. With a maximum audience of about 700 people, the conditions are improved. One rather surprising feature in the acoustics is the satisfactory rendering of vocal music. This was not anticipated, but it would seem that a room acceptable for speaking is also suited for vocal music. Instrumental music, such as that of a piano, is heard at a disadvantage. For this, the room is too "dead."

The two auditoriums described indicate the degree of development of the acoustical design of auditoriums. The theory and practice have been tried in many cases with success. There appears to be some range of latitude in the acceptable time of reverberation and in the intensity of the resulting sound so that the amount of sound absorbing material recommended for a room may be varied within certain limits without prejudicing seriously the successful outcome.

In addition to the acoustical design of auditoriums, another problem in buildings presents itself — namely, the sound proofing of rooms. Great annoyance and inconvenience are suffered because of the unwelcome intrusions in a room of sounds coming from other parts of the building. The noise of a piano in an adjoining apartment, the hum of a motor, the click of typewriters, etc., are familiar instances of sounds that annoy people and reduce their efficiency in the performance of work.

The sound proofing of rooms to reduce this defect is not a simple matter, nor is it attended with the same certainty of success as in the acoustical design of auditoriums. Sound progresses along unsuspected paths so that practical attempts to stop it, even if based on the suitable theory and in accord with other successful insulations, are not always effective.

In this connection, two kinds of sound should be considered. First, those generated by the voice, a violin, etc., which originate in the air and proceed through the air. These are reflected in large proportion when they strike a continuous wall of some rigidity. Another type of sound originates in the vibrations of a piano, cello, motor, etc.— instruments which make an intimate contact with the building structure. These vibrations travel with ease through the continuity of structure and are converted into sound in air, even at distant points in the building, when a wall or some structural member responds in a resonant way to the vibrations. The insulation for this latter type of vibration lies in the interposition of some medium varying in elasticity or density from the medium in which the vibrations are traveling. Thus, an air space inserted in

masonry would be quite effective in stopping sound, provided the air space were not bridged over by solid material. But the practical requirement of rigidity does not allow the interposition of an unbridged air space, so that the next best arrangement is used, namely, hairfelt or some other air filled material as part of a floating floor, double wall, etc. The problem is not yet solved in a practical way for all conditions; but progress has been made.

For instance, in the Smith Music Building already mentioned, an effort was made by the Supervising Architect and the writer to sound proof the entire building from attic to basement. This problem involved the sound insulation of some fifty small practice rooms, twelve studios, and the larger concert hall, besides the acoustic control of sounds of motors, fans and elevators. Double walls, floors, and ceilings were constructed in accordance with the descriptions set forth in the previous paragraph. Tight fitting doors and windows were specified to prevent leakage of sound and separate ventilation ducts were designed to convey air to and from each room.

Without dwelling on all the details it is perhaps sufficient to state that some degree of success attended the efforts. Students use adjacent rooms for piano practice, singing, violin and other instrumental drill, etc., without serious disturbance to each other. The rooms are not absolutely sound proof nor does this appear necessary because the sound that leaks into the room is so diminished in intensity that it is unnoticed when practice is in progress. The ventilators transmit sound between different parts of the building, but the use of separate pipes for each room diminishes the intensity of these transmitted sounds so that they become unimportant compared with sounds generated in the room itself.

After several months of use, the building is considered satisfactory for the purpose. Absolute sound proofing cannot be attained without very unusual, and perhaps impractical, building constructions. It appears from the experience with the Music Building thus far that absolute sound proofing is not essential. There are many things

yet to be learned by further experience, but enough has been revealed to give encouragement to the belief that sound-proofing may be prescribed in the near future with some of the certainty that now attends the acoustic design of auditoriums.

Department of Physics
University of Illinois
February, 1921.

NOTE ON THE CHARACTERISTICS OF THE NEW SINGING TUBE[1]

PROF. CHAS. T. KNIPP, UNIVERSITY OF ILLINOIS

The temperature difference that is necessary to cause the new singing tube to emit a tone, when the portion B (Fig. 1) is kept at room temperature while the tip A is heated, was observed to be about 400° Centigrade. If, however, B is cooled to the temperature of liquid air the temperature difference necessary is greatly reduced, being about 200° Centigrade. The pitch is also considerably lowered.

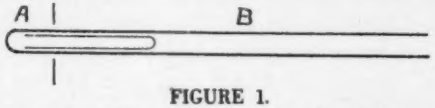


FIGURE 1.

It was deemed desirable to make quantitative measurements of these temperature differences and also of the corresponding pitch of the tone emitted. To this end B was held successively at different temperatures, ranging from that of liquid air to values considerably above room temperature, while A was heated electrically in each case to a temperature where a tone was emitted continuously. The two portions A and B were each housed within a separate copper tube of about 1 cm. wall thickness and heavily insulated with asbestos. The temperatures were accurately measured by means of thermo-junctions—three being attached to A and three to B. The temperature control of each section was good and could be held fairly constant at will.

TABLE I.

Obser-nation No.	A Average Temp. in degrees C	B Average Temp. in degrees C	Total temp. difference in degrees C	Temp. of B in absolute measure	Vibra-tions per second
1	1	−181	182	92	213
2	204	− 88	292	185	300
3	355	− 16	371	257	378
4	448	+ 26	422	299	425
5	524	+ 57	464	330	450

The results from the only run thus far made are contained in Table 1. In observation No. 1 the part B was placed within a glass jacket heavily wrapped with asbes-

1. Phys. Rev., N. S., Vol. XV, p. 336.

tos and cooled directly to -180°C by means of liquid air. The temperature of A was allowed to fall until the tone emitted was just maintained. This by repeated trials was found to be at 1°C. Thus the temperature difference when B was cooled to -181°C, for this particular tube, was found to be 182°C. In observations 2 and 3 the part B was placed in a special copper tube designed by the author[1] some years back for the determination of intermediate temperatures. Observation 4 was for B at room temperature (note that it was now necessary to heat A to 448°C), while in No. 5 the part B was warmed up to 57°C, and the tip heated electrically to 527°C before the tube responded.

The absolute temperatures of the part B are given in the second last column, while the corresponding vibrations per second are listed in the last column. These data are represented graphically in Fig. 2, in which the total temperature differences as ordinates are plotted against absolute temperatures. The relation is strictly linear except possibly for the last reading at 330° absolute temperature. By extending the straight line to the left we are able to determine the temperature difference that should maintain

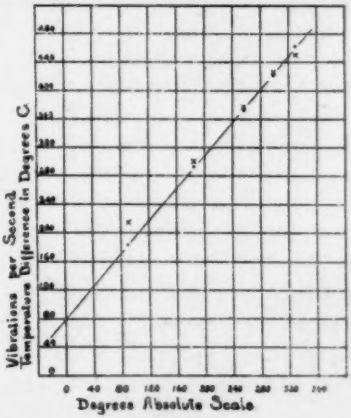


FIGURE 2.

the tone when B is cooled to absolute zero. For this particular tube the graph shows this temperature difference to be about 80°C.

1. Phys. Rev., Vol. XV, p. 125.

The same figure also shows the corresponding vibration frequencies (indicated by crosses) plotted to the same scale against absolute temperatures. This relation also seems to be linear except for the point taken at 91° absolute. The pitch was determined by means of a tone variator.

Lastly the vibration frequencies and temperature differences in degrees centigrade, as shown by the graphs, are nearly equal numerically. This, however, should be considered as a coincidence.

Observations with tubes of different pitches and extending over wider temperature ranges are under way.

Department of Physics
University of Illinois
February, 1921.

A WEHNELT CATHODE FOR THE EMISSION OF A SMALL, COMPACT AND PERMANENT BEAM OF ELECTRONS

PROF. C. J. LAPP, UNIVERSITY OF ILLINOIS

A hot line Wehnelt cathode has been constructed by means of which a very small and compact permanent beam of electrons may be secured through the application of barium resinate and strontium hydroxide to a platinum strip. Heretofore when an experiment was performed requiring a small beam, two methods were available, one in which a tiny speck of either calcium chloride or Bank of England sealing wax was used and the other in which a small beam is obtained from a larger one by means of a platinum diaphragm. The disadvantage of the former is that the beam is not permanent, lasting at times but a few minutes; while the latter can not be used to advantage in strong magnetic fields since the beam is deflected to one side and fails to pass through the opening in the diaphragm.

A strip of platinum 0.5 mm. wide was cleaned with nitric acid and ammonium hydroxide. A tiny drop of strontium hydroxide was placed on the strip, after which it was dried by gently heating the strip by means of an electric current. After two applications the platinum strip was heated red in order to harden the deposit. A small and almost microscopic piece of barium resinate was then placed centrally on the spot and the whole carefully heated so as to evaporate the resin and have barium oxide. After two or three coats of barium oxide the strip was glowed to cherry red for several minutes in order to drive off all organic material. A coating of approximately 0.1 mm. in diameter was thus obtained which gave an intense and compact permanent beam of electrons without the use of a diaphragm. A beam of this nature has been long sought after in this laboratory and is now available for a number of uses.

Laboratory of Physics
University of Illinois
April, 1921.

PRELIMINARY NOTE ON THE ELECTROMAGNETIC INDUCTIVE PROPERTIES OF A CATHODE RAY SOLENOID

PROF. CHAS. T. KNIPP AND C. S. PALMER
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That a cathode ray solenoid should possess electromagnetic inductive properties of a magnitude that can be measured (or rather detected) by a suitably high sensitivity galvanometer has been more or less apparent to one of the writers for a number of years. It was suggested by Rowland's classical experiments on the equivalence of a moving charge to a current of electricity. However, it was not until recently that it was decided to put the experiment to a test. That the electron composing the cathode ray beam is deflected by either an electrostatic or a magnetic field is well known, and, in itself, is evidence enough of its equivalence. If now the cathode ray beam be used to induce a current in a neighboring wire through its purely electromagnetic action, then such an induced current should be regarded as additional evidence of the equivalence of a moving charge to a current of electricity.

The arrangement of the apparatus, Fig. 1, proposed to test this point, is to form within a suitably designed cathode ray discharge tube, by means of a powerful external magnetic field (in which H is of the order 50 gausses), a cathode ray solenoid having the approximate dimensions: length,

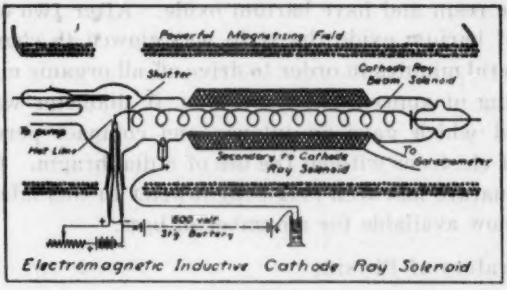

FIGURE 1.

40 cm.; diameter, 2 cm.; and pitch, 1 cm. This solenoidal beam is made to pass through a glass tube, which is an

extension of the discharge tube, and which carries over a considerable portion of its length a secondary of many turns of copper wire. The cathode ray solenoid, i. e., the spiral cathode ray beam within, is thus made the primary of a vacuum cored transformer, the secondary of which is connected to a low resistance high sensitivity galvanometer. The charge caused to circulate through the galvanometer on interrupting the cathode ray beam, or on allowing it to pass, is, to a first approximation,

$$Q = K_2 d = 4\pi \frac{n_1 n_2 A I}{10^9 R} \quad \cdots \quad (1)$$

where n_1 is the number of turns per centimeter length of the primary, n_2 the total turns in the secondary, A the mean area of the primary, I the current in amperes flowing through the cathode ray solenoid, and R the total resistance in the secondary. Since the secondary has a comparatively low resistance the damping of the galvanometer will be considerable, and hence its ballistic constant, K, becomes a function of the resistance R. Under these conditions the galvanometer may be calibrated readily and thus the order of the deflection that should result on making or on interrupting the beam, for a given current I, becomes known.

As in experiments of this kind, it is wise to test the set-up before going farther and get some idea of the magnitude of the quantity of electricity induced in the secondary by known values of I made or broken in the primary, i. e., to see whether the effect sought will produce measurable deflections of the galvanometer. To make this preliminary test we placed down through the central tube, where the cathode ray spiral was supposed to go, a copper wire spiral having the same pitch (turns per centimeter) and diameter as the proposed solenoidal cathode ray spiral. Then, on making or breaking the current through this, we read the corresponding induced current in the secondary,—this being proportional to the deflection of the galvanometer. Thus deflections of the galvanometer were obtained for a number of different values of I in the primary. The values are contained in Table I.

TABLE I

I amperes in primary	Galvanometer deflections in mm.	Galv. deflec. in mm. calculated by means of equation (1)
.1	27.5	29.7
.05	13.5	14.85
.035	10.0	10.39
.015	3.8	4.45
.005	1.0	1.48

We see from this table that in order to get a galvanometer deflection of about 27mm. the equivalent current flowing through our cathode ray solenoidal beam must have the value of .1 ampere, while .005 ampere will give a deflection of only 1 mm. Intermediate values of I give intermediate deflections. Obviously, the current must exceed .005 ampere in order to be detected, and to be measured with fair accuracy the current flowing through the beam should be of the order of .05 ampere.

Two methods are available for the interruption of the cathode ray beam. The simplest, from a manipulative standpoint, is to break, at some external point, the high potential direct current supplied to the hot lime cathode. However, the most effective and theoretically correct method is to interrupt the beam by a shutter just before it enters the tube on which the secondary is wound. This shutter is operated from the outside through a ground joint. The general arrangement of the various connections is shown in Fig. 1.

In this preliminary report we may say that the order of magnitude of the cathode ray current that we were able to get in the few trial runs thus far made was about .005 ampere,—thus the effect was just detectable. We expect to increase the current flowing through the electron solenoid at least ten times, by using a larger source of electrons and also by introducing hydrogen into the tube. When this is done no difficulty will be experienced in measuring quantitatively the effect sought.

Department of Physics
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April 27, 1921.

EFFICIENCY TESTS OF THE NEW CENCO-HYVAC OIL VACUUM PUMPS

PROF. CHAS. T. KNIPP AND C. S. PALMER
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The Department of Physics at the University of Illinois has been interested in high vacuum work for a number of years. The new types of mercury vapor condensation pumps that are now generally used in the production of exceedingly high vacua require supporting pumps that will draw a fairly high vacuum of, say, .01 to .001 mm. of mercury, and maintain it after weeks and months of continued use. Such pumps, if moderately priced, are much in demand at the present time.

Last December, at our request, the Central Scientific Company of Chicago sent one of their new design Cenco-

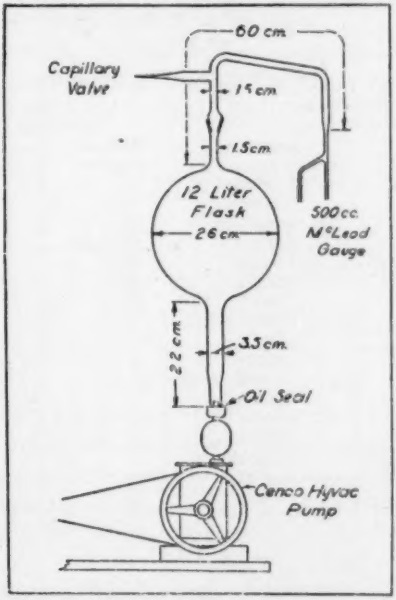

FIG. 1.

Hyvac oil pumps to our laboratory. We wished to test it for speed and endurance. It was inconvenient at the time

to make the speed tests since a pump was sorely needed as a fore pump in the junior electrical measurements work, and later also in research. The pump was put to work at once and has been in almost continuous use three days per week ever since.

Just recently (in April) it was arranged to try it out quantitatively. To this end the pump was connected directly through a short large diameter tube to a 12 liter flask which had attached to it a 500 cc. McLeod gauge for measuring the pressure, making with the connecting tubes 13 liters as the total volume to be exhausted. The connections and dimensions of the various parts are shown in Fig. 1. In a test like this it is necessary that all connecting joints be absolutely tight. The only two in this set-up, the one connecting to the pump, and the other to the McLeod gauge, were protected by heavy oil seals. The test consisted in noting the time and reading the corresponding pressure.

TABLE I.

Cenco-Hyvac Oil Pump No. A112

13 liter volume RPM Equals 225		1.3 liter volume RPM Equals 225	
Time in minutes	Pressure in mm. mercury	Time in minutes	Pressure in mm. mercury
30	.00786	4	.01152
35	.00340	6	.00234
40	.00200	8	.00133
45	.00158	10	.00105
50	.00139	12	.00103
55	.00131	17	.00092
60	.00119	27	.00090
65	.00117		
70	.00115		
80	.00109		
90	.00100		
100	.00098		
110	.00094		
120	.00092		
130	.000911		
140	.00090		
170	.00084		

TABLE II.

Cenco-Hyvac Oil Pump No. A186

13 liter volume RPM Equals 224		6 liter volume RPM Equals 214		1.3 liter volume RPM Equals 230	
Time in Minutes	Pressure in mm. Mercury	Time in Minutes	Pressure in mm. Mercury	Time in Minutes	Pressure in mm. Mercury
25.....	.01260	15.....	.00564	4.....	.00832
30.....	.00480	17.5.....	.00210	6.....	.00279
35.....	.00154	20.....	.00132	8.....	.00165
40.....	.00084	22.5.....	.00093	10.....	.00124
45.....	.00065	25.....	.00076	12.....	.00095
50.....	.00060	27.5.....	.00073	17.....	.00079
55.....	.00057	30.....	.00070	22.....	.00062
65.....	.00056	35.....	.00067	27.....	.00051
85.....	.00056	40.....	.00065		
105.....	.00055	45.....	.00062		
505.....	.00037	55.....	.00058		
		65.....	.00053		
		75.....	.00051		
		85.....	.00050		

Readings were taken at five or ten minute intervals over a period of several hours. The revolutions per minute of the pump were also noted from time to time.

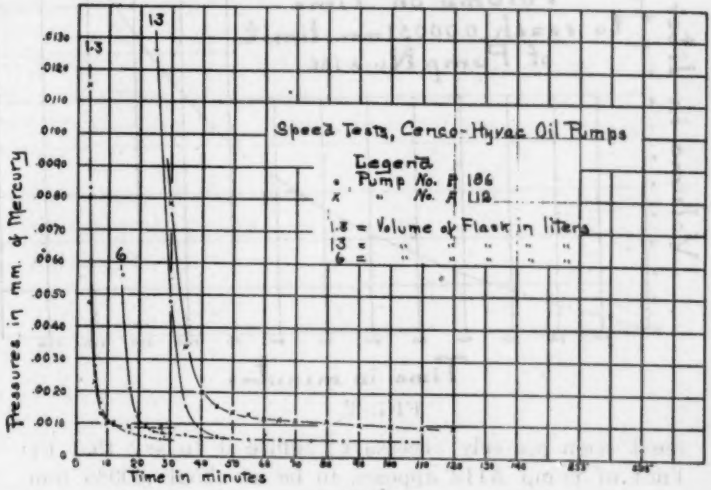

FIG. 2.

After completing the run with the 13 liter volume it was replaced by a glass tube of about 3.5 cm. diameter, making the total volume now to be exhausted but 1.3 liters,—

exactly one-tenth the former volume. Readings at 5-minute intervals were again taken. The data relative to this pump with these two volumes are contained in Table I.

Just recently (April 11) the department purchased a second Cenco-Hyvac oil pump. This was at once connected up as shown in Fig. 1, first with the 13 liter volume, then with a 6 liter volume, and finally with the 1.3 liter volume. The running conditions, etc., were exactly the same as in the first pump. The data relative to these three volumes are contained in Table II.

The data in Tables I and II are plotted in Fig. 2, in which the crosses represent pump No. A112, received in December, 1920, and the dots pump No. A186, purchased recently. A careful study of the tables and curves makes further com-

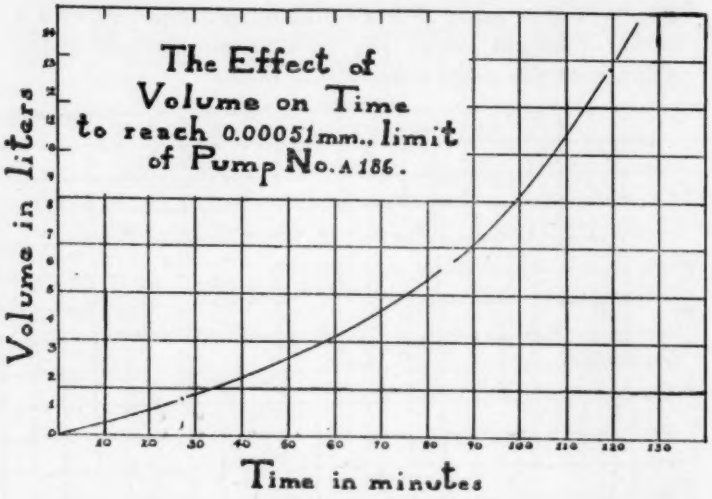

FIG. 3.

ment seem scarcely necessary; suffice it to say that the limit of pump A112 appears to be at about .00085 mm. mercury, while that of pump A186 is about .0050 mm. mercury. Tags attached to the pumps indicated .001 mm. mercury for A112, and .00055 mm. for A186. Thus the data obtained in our laboratory place the respective limits at

pressures that are lower than those claimed by the company. Furthermore, it appears that pump A112 has improved with use.

The relative speed of exhaustion of the two pumps is also shown by the curves. In general the speed is a complex function of the volume exhausted, the time, and the pressure at the beginning and at the end, and need not be considered here. It should be noted, however, that it required about 27 minutes to reach the limit (.00051 mm. of mercury) in exhausting the 1.3 liter volume, while approximately 85 minutes were required to reach the same limit in the case of the 6 liter volume, and 120 minutes to reach the above limit when the 13 liter volume was exhausted. This relation is best shown by the curve in Fig. 3, where volume in liters is plotted against time in minutes required to reach the limit .00051 mm. This curve is for pump No. A186.

The foregoing data show that this type of oil vacuum pump is quite rapid, and reaches a surprisingly high vacuum. It is therefore well suited to be used as a fore pump to any large throated rapid acting mercury vapor pump, since there is ample overlapping—a necessary condition in any system of exhaustion where fore or supporting pumps are used.

Laboratory of Physics
University of Illinois
April, 1921.

Constitution and By-Laws

CONSTITUTION AND BY-LAWS*

Illinois State Academy of Science

CONSTITUTION

Article I. Name.

This Society shall be known as The Illinois State Academy of Science.

Article II. Objects.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

Article III. Members.

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members.*

National Members shall be those who are also members of the American Association for the Advancement of Science. Each national member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of five dollars.

Local Members shall be those who are members of the local Academy only. Each local member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members, Active Members,* or *Non-resident Members.*

Life Members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars. Life members, if national members, shall pay an annual assessment of four dollars.

Active Members shall be national or local members who reside in the State of Illinois, and who have not paid as much as $20.00 in fees to the Academy.

Non-resident Members shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

Charter Members are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

Article IV. Officers.

The officers of the Academy shall consist of a President, a Vice-President, a Librarian, a Secretary, and a Treasurer. The chief of the Division of State Museum of the Department of Registration and Education of the state government shall be the Librarian of the Academy. All other officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

*As Revised February, 1920.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, Vice-President, Librarian, Secretary, Treasurer, and the President of the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

Article VIII. Publication.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting.

IX. The Secretary and Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

List of Members

List of Members

Note—The names of charter members are starred; names in black faced type indicate membership in the American Association for the Advancement of Science.

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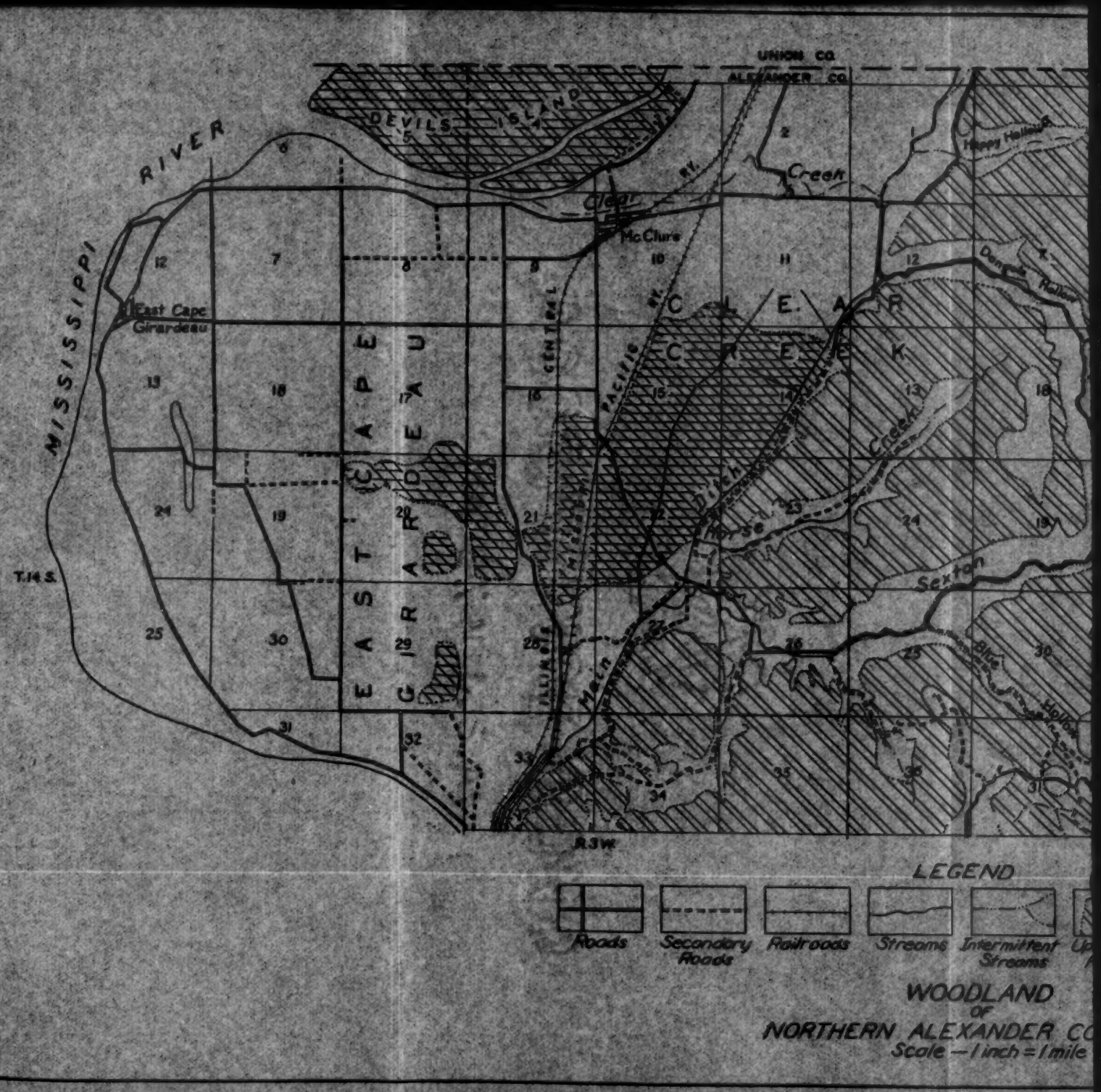
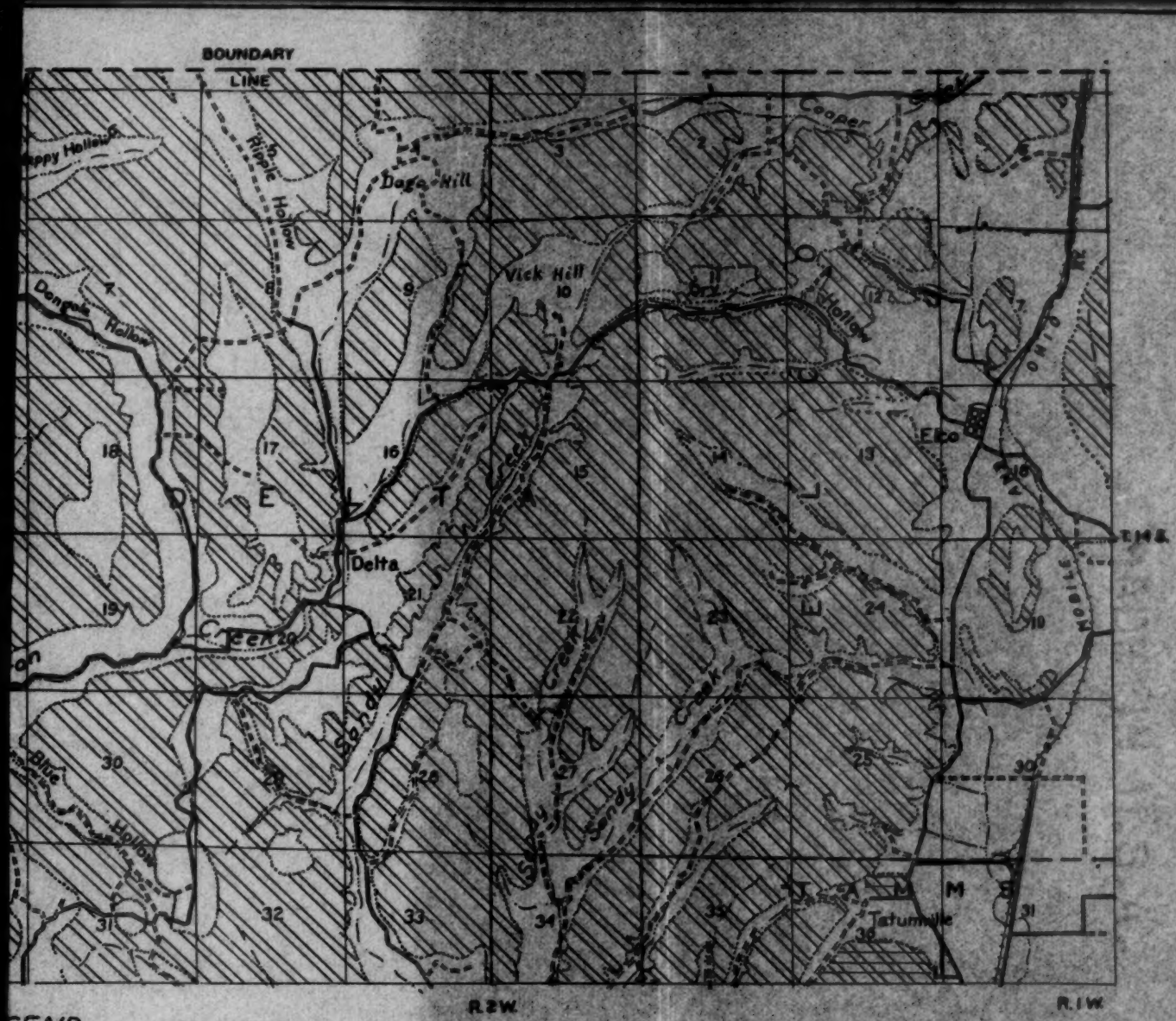

UNION CO.
ALEXANDER CO.
DEVILS ISLAND
MISSISSIPPI RIVER
Happy Hollow
Creek
Clear
McClure
East Cape Girardeau
CAPE GIRARDEAU
CENTRAL
PACIFIC RY.
CLEAR CREEK
Horse Creek
Sexton
Main
ILLINOIS
Dennis Ridge
Blue
Hollow
T.14 S.
R.3 W.
LEGEND
Roads
Secondary Roads
Railroads
Streams
Intermittent Streams
WOODLAND
OF
NORTHERN ALEXANDER CO
Scale — 1 inch = 1 mile



GEND

Intermittent Streams | Upland Forest | River Bottom Forest | Cypress Swamp Forest

ODLAND
OF
EXANDER COUNTY, Ill.
—1 inch = 1 mile

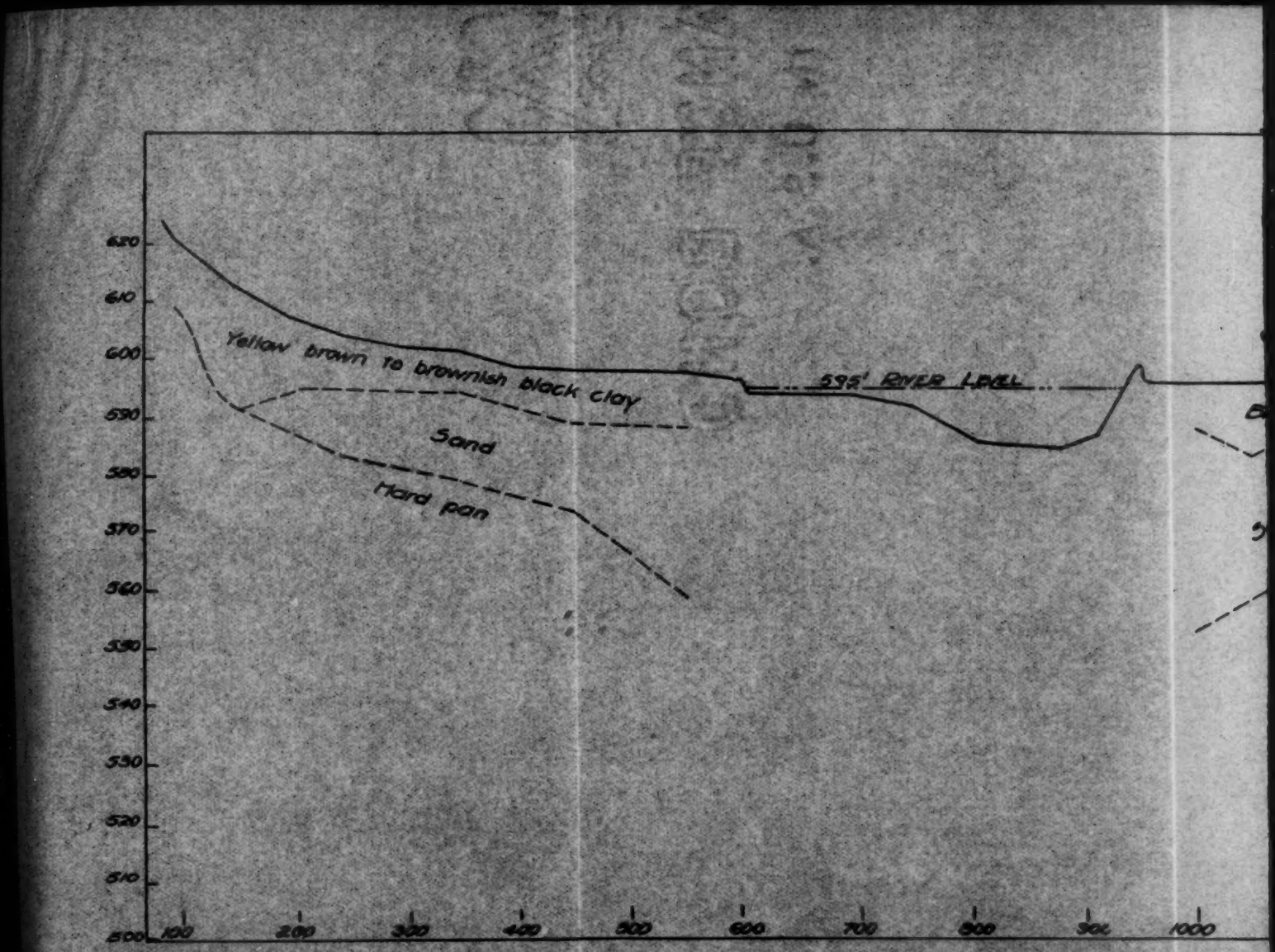
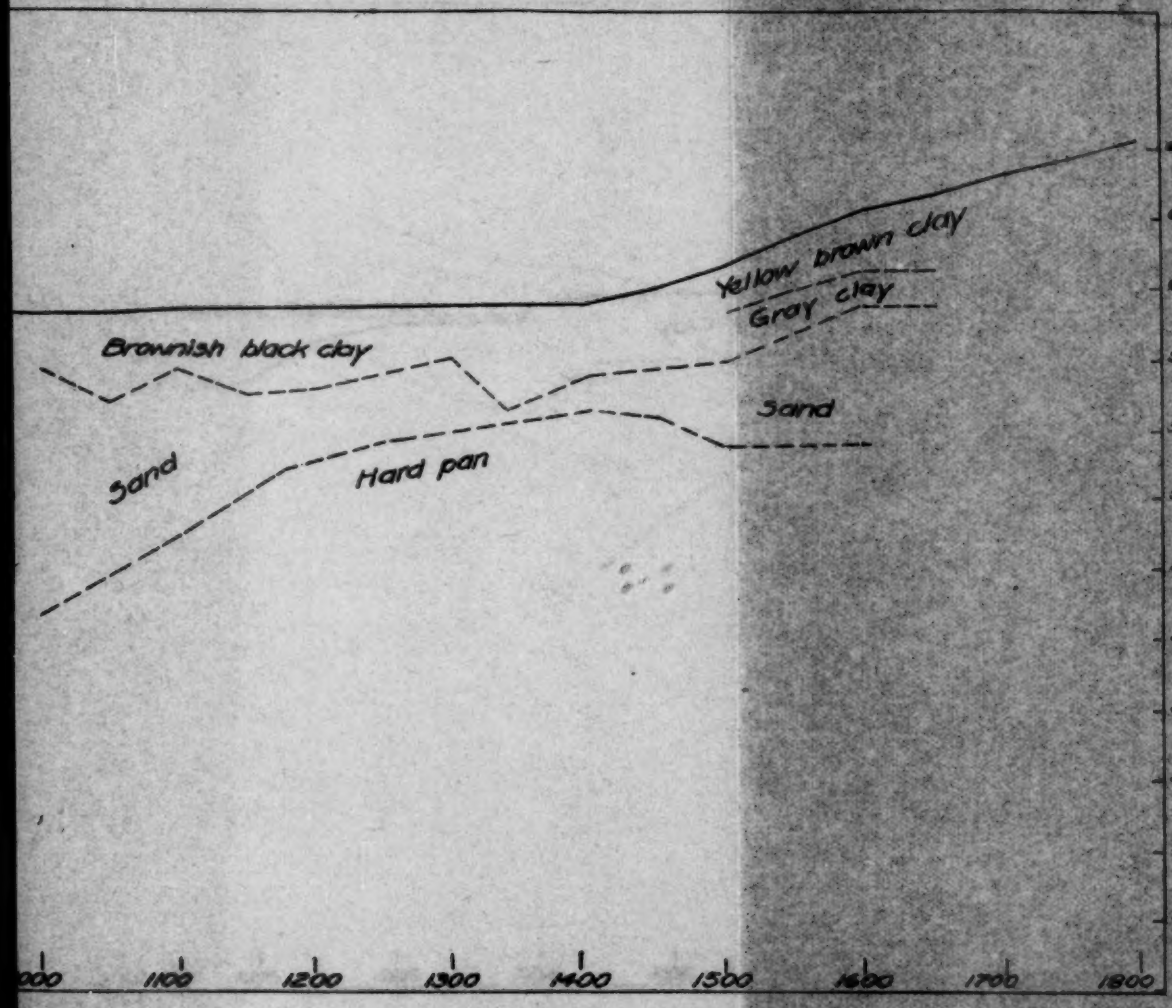


FIGURE 1. Cross-section diagram of the Sangamon River Valley at the Decatur dam site, show
as shown by exposures and borings.



1" = 100'
2" = 10'

site, showing the relation of the materials beneath the surface
nd borings.